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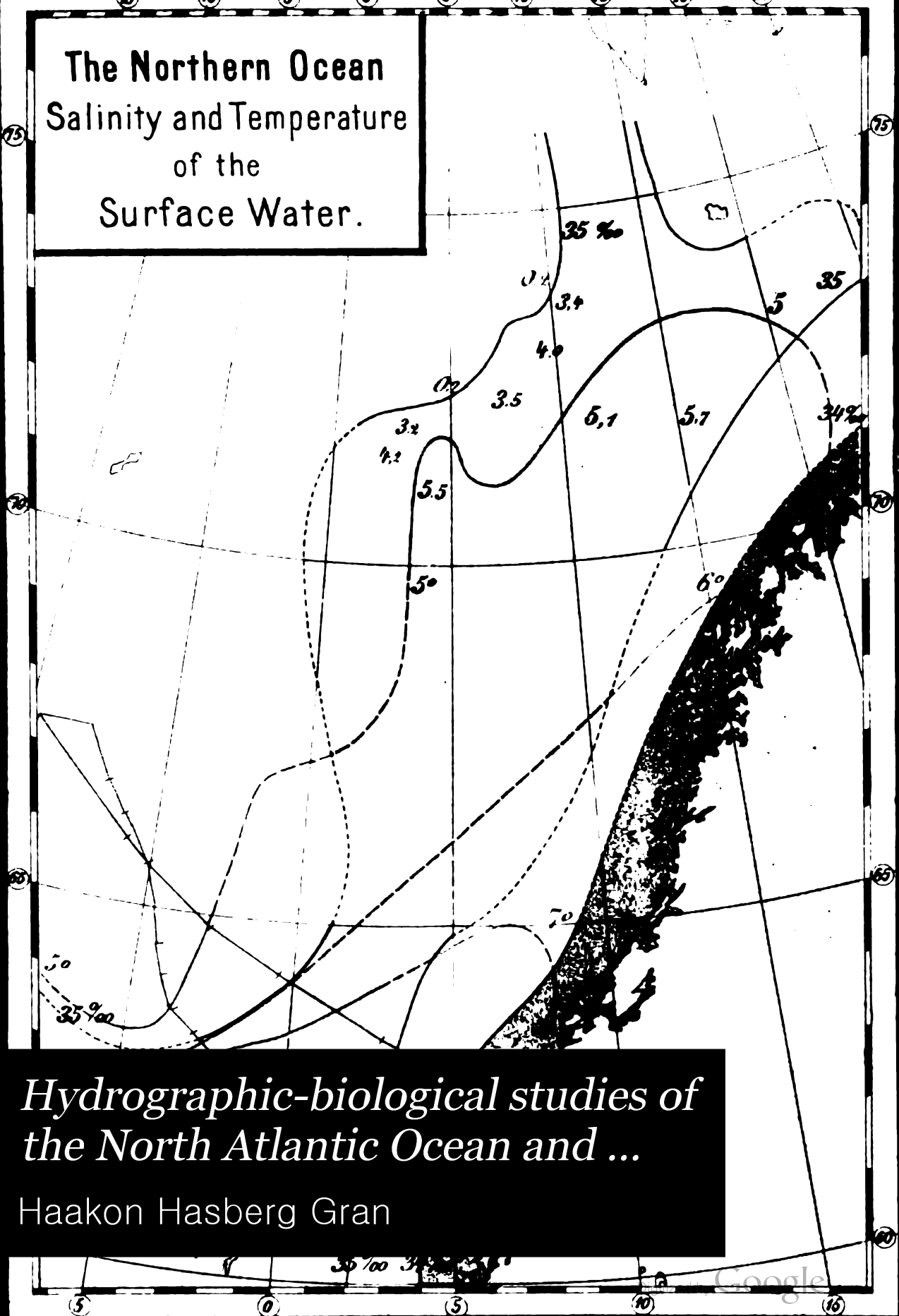
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# The Northern Ocean Salinity and Temperature of the Surface Water.



*Hydrographic-biological studies of  
the North Atlantic Ocean and ...*

Haakon Hasberg Gran

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W. G. FARLOW.









Report on Norwegian Fishery- and Marine-Investigations Vol. I 1900 No. 5.

HYDROGRAPHIC-BIOLOGICAL STUDIES  
OF  
THE NORTH ATLANTIC OCEAN  
AND  
THE COAST OF NORDLAND

BY  
H. H. GRAN

WITH 2 PLATES



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OSCAR ANDERSENS BOGTRYKKERI  
1900

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## Introduction.

**I**n this paper the results will be recorded of the hydrographical observations in the North Atlantic Ocean, which were made in 1898 at the instigation of the Norwegian fisheries investigations, under the direction of *Dr. Johan Hjort*.

They are principally observations of the temperature and salinity of the surface at different periods of the year; the material has been procured through the kind assistance of captains of private steamers, as will be seen from the following pages, where the name of the observer is always given. Moreover a series of deep-sea observations has been made by Captain *Bie*, assistant in the investigation, on *H. M. S. Heimdal*, with which, through the kindness of the Admiralty, he was allowed to accompany the expedition.

During the last two summers, the present author has examined the hydrographic and biological conditions of the sea and the fiords along the Nordland coast, with the special object of obtaining a general view of the hydrographic conditions at that season of the year, when the arrival of the summer herring takes place.

Plankton series have been procured for all seasons of the year, by the kind assistance of private individuals, from Herø in Helgeland and from Røst.

The first section treats of the observations taken on steamer routes across the North Atlantic; the second section gives an account of the investigations on the coast of Nordland.

On behalf of the direction of the investigations, I beg to thank the private and public individuals and institutions, that have contributed by their kindness towards the promotion of this work.

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# I. The North Atlantic Ocean.

## 1. Hydrographic Investigations.

Upon the basis of *O. Pettersson's* and *Cleve's* epoch-making researches, a whole literature has of late years come into existence on the subject of the hydrographic and biological conditions of the Norwegian North Atlantic.

One of the most important problems still awaiting its solution, is the relation between the east Icelandic polar current on the one hand, and the Gulf Stream on the other.

It is well known that *O. Pettersson* has advanced the hypothesis that in the winter the polar current increases so greatly in extent, that in certain years, at any rate, it breaks through the Gulf Stream, and pours its volumes of water into the North Sea and the Skagerrak. It was the annual hydrographic changes in the Skagerrak, that suggested this idea to *Pettersson*, and he was confirmed in his view by the fact that *Cleve* [96, 97]\* and *Aurivillius* [96, 98] found arctic plankton organisms on the shores of the Skagerrak in the winter.

The object was thus to investigate the conditions out in the North Atlantic itself during the winter. No other investigations had as yet been made of that region except the taking of surface-temperatures, which *Mohn* [87] through a series of years had collected with the assistance of Norwegian sealers and whalers. By means of these observations, *Mohn* was enabled to construct the chart of the mean temperature of the surface of the sea in the month of March, which he published in his valuable

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\*) The Bibliography is referred to by numbers indicating the year of publication of the treatise placed between brackets [ ] after the name of the author.

treatise in the Report of the Norwegian North Atlantic Expedition (l. c. Pl. XXVIII).

The first investigations of the salinity in the North Atlantic in the winter, were carried out under the direction of *Dr. Johan Hjort*. Through the kind assistance of Norwegian sealers, he was enabled to procure material for a hydrographic map of the surface of the North Atlantic in March, 1897, which was published in a preliminary account in «*Naturen*» (*Hjort* [97]), and later in a longer treatise by *Hjort & Gran* [99].

This map showed that *O. Pettersson's* theory was correct in so far as the polar current in winter is much greater in volume and extent, than had previously been supposed; and that the Gulf Stream was much less powerful than it is known to be in the summer.

On the other hand, it appeared that the Gulf Stream, even in March, was powerful enough to form a barrier from the Faroe Isles and the Shetland Isles, past the northern part of the North Sea, so that it was not possible to imagine that the polar current could break through it. As March is the coldest month of the year in the sea, we thought it likely that the polar current in that month would be at its maximum, and the Gulf Stream at its minimum, so that it was highly probable that at no other period either, of the winter of 1896—97, had the polar current forced its way into the North Sea.

Two series of deep-sea investigations right across the North Atlantic, which *Hjort* had carried out on board the corvette *Heimdal* in May, 1896 and 1897, were also of great interest, as they showed that the relative volume of Arctic and Atlantic water was different at the same period in different years. While the Gulf Stream in the middle of May, 1896, was of great expanse and with a high surface-temperature (above 9°), in 1897 it was quite narrow, not much broader than in March of the same year, and the thermometer did not rise above 7.8° anywhere.

The continuation of the investigations was therefore a matter of the greatest interest; but unfortunately no winter expedition could as yet be sent out with this object, and recourse had to be had to the assistance of captains of private steamers. *Pettersson* has given a preliminary account [99,2] of two steamship routes across the North Atlantic in March, 1898. One of these shows, that in about 65° N. Lat. the Gulf Stream was either very narrow, or overflowed by the fresher and colder polar water, while both south and north of this, it was more expanded. *Pettersson*

is of opinion that the polar current here has broken through, and that earlier in the winter the point where it overflowed the Gulf Stream has been situated farther south.

The Norwegian investigations directed by *Dr. Hjort*, obtained at the same time observations on two steamer routes, S.S. *Westye Egeberg*, Capt. *L. Tufte* and S.S. *Heimdal*, Capt. *H. C. Hansen*. The latter route (Table 3) unfortunately went south of the Faroe Isles to the south of Iceland, so far south that it did not touch the polar current. It is therefore of less importance to the solution of the question before us, and moreover covers almost the same field in which observations are regularly made by Danish observers all the year round.

The «*Westye Egeberg's*» route (Table 2), on the other hand, is from the west coast of Norway straight up to Jan Mayen. The observations give the same results as the line mentioned by *Pettersson*, namely that in  $65^{\circ}$  N. Lat. the salinity diminishes to  $34.80\text{‰}$ , and the temperature falls to  $4^{\circ}$  C. There is thus undoubtedly an admixture of polar water here. To the north and south, the surface-temperature exceeds  $5^{\circ}$  C. and the salinity is more than  $35\text{‰}$ , thus showing that here the volumes of the Gulf Stream flow in a fairly unmixed condition right up to the surface. The «*Westye Egeberg's*» route lies a little to the east of *Pettersson's* line, and that part of it in which the salinity is below  $35\text{‰}$ , is a little shorter than in *Pettersson's*. It is, however, so long, that with *Pettersson* I may assume that the layers of arctic admixture were here in a line with the sea off the coast of Nordland, and that in  $65^{\circ}$  N. Lat., the surface of the Gulf Stream was broken into.

*Pettersson's* supposition that the overflowed part lay farther south earlier in the winter, so that it has been possible for arctic water to enter the North Sea, is a hypothesis which still requires confirmation.

The results hitherto obtained show however with certainty, that early in March, 1898, the Gulf Stream had its weakest point at a latitude of about  $65^{\circ}$  N.

This was also the case in March, 1897. The surface map (*Hjort & Gran* [99] Pl. 3) and the tables (l. c. Tab. B IV a, b, pp. 13, 14) shew that just about  $64$  and  $65^{\circ}$  N. Lat. there was a slight decrease both in temperature and salinity. The observations were rather too few to afford certain proof that the polar current here communicated with the sea along the Norwegian coast; but it is not impossible that a communication such

as this also occurred in March, 1897. On the other hand, the same map plainly shows, as we also pointed out, that the polar current does not enter the North Sea, but rather forces the Atlantic water into it.

Even as late as May, in 1898, it may be seen that the Gulf Stream has its narrowest point at about  $65^{\circ}$  N. Lat.

The Norwegian investigations have obtained a great many observations through the kind assistance of two Tromsø captains, Capt. *Fr. Svendsen* (S.S. »Hvidfisken«) and Capt. *J. Svendsen* (S.S. »Jasai«), and from the cruise of the corvette »Heimdal« in the Arctic Ocean, so that I have been able to make a map of the surface for the month of May (Pl. I).

Unfortunately there are no observations from the eastern part of the North Atlantic, between  $64^{\circ}$  and  $71^{\circ}$  N. Lat., but it is nevertheless sufficiently evident, that the water of the Gulf Stream, with its great salinity, occupies a large portion of the surface of the northern part of the North Atlantic, while in  $64^{\circ}$  N. Lat. it is compressed into a narrower band.

The Heimdal's course is marked upon the map with a black line, the stations of deep-sea soundings with small circles (ctr. Tab. 4. 5).

The observations in the northern part were taken on sealing expeditions; and as sealers prefer to keep near the boundary between the Atlantic and the Arctic waters, this part of the map is drawn from very abundant data (Tab. 6, 7).

The map shows that the curves of salinity and temperature do not quite coincide. At  $63^{\circ}$  and  $64^{\circ}$  N. Lat. the  $35\text{‰}$  salinity curve almost coincides with the temperature-curve for  $6^{\circ}$  and at  $72^{\circ}$  and  $73^{\circ}$  with the temperature-curve for  $3^{\circ}$  C.

The Heimdal's course from Bergen to the Arctic Ocean is of special interest, because corresponding observations have been made at the same time of year, for the two years preceding (*Hjort & Gran* [99] Tab. A III, V and Pl. IV), thus enabling a comparison to be made. The volume of the Gulf Stream in May, 1898, had not nearly so great a superficial extent as in 1896, but greater than in 1897. With regard to the temperature also, 1898 stands between 1896 and 1897; in 1896 the highest surface-temperature was  $9.6^{\circ}$ , in 1897,  $7.8^{\circ}$ , and in 1898,  $8.3^{\circ}$ . In 1898, the Atlantic water went closer up to the Norwegian coast than in the two preceding years, and it was found nearer the surface. During the latter part of the cruise unfortunately, no deep-water investigations could be made on account of stormy weather.

In 1897, it appeared that the hydrographic conditions in this part of the North Atlantic had altered little between the months of March and May; the temperature had risen everywhere, but the salinity had remained almost unchanged, so that the Heimdal's observation-line in May might have been drawn on the surface map for March, without essentially disturbing the saline curves. The case appears to be the same in 1898, »Westye Egeberg's« line for the month of March agrees very well with the map for May, in tracts where observations are to be had for both months. Thus in the spring, from March to May, the Gulf Stream has its narrowest point on the surface, at about  $65^{\circ}$  N. Lat.

The abundance of observations recently published from the Danish Ingolf Expedition, (*Martin Knudsen* [98]) shows, however, that the *east Icelandic polar current* can also reach much farther towards the south-east in the summer, than was formerly supposed. Even in the months of July and August, 1896, water was found with a salinity of less than  $35\text{‰}$  in  $63^{\circ}$ — $64^{\circ}$  N. Lat. quite as far to the east as north of the Faroe Isles, probably still farther (l. c. Pl. XXXII). This water had a temperature of from  $8^{\circ}$  to  $10^{\circ}$  while the volume of the Gulf Stream was above  $11^{\circ}$ . Both temperature and salinity thus indicate a connection with the polar current. On a sketch-map that *Pettersson* made from the results of the Ingolf Expedition, he has drawn the  $35\text{‰}$  curve in such a manner that in  $65^{\circ}$  N. Lat., it reaches farthest towards the east, up to about  $4^{\circ}$  W. Long. (*Pettersson* [99, 1], p. 142, fig. 1).

Similar conditions prevailed in the summers of 1897 and 1898. In both these years, water-samples were collected and the surface-temperatures taken by Capt. *L. Tufte* on his voyage home from the north of Iceland to the North Sea. The results will be found on Tables 12 and 13, a graphic representation being moreover given of them on Pl. II, figs. 1, 2. In 1897, water of undoubted arctic origin was found on the surface as far south as  $62^{\circ}27'$  N. Lat.,  $3^{\circ}18'$  W. Long.; and in 1898, as far as  $62^{\circ}53'$  N. and  $4^{\circ}30'$  W. It thus seems as if the polar current in July, 1897, had gone more to the east than in 1898. This is not decided, however, as the route in 1898 lay a little more to the south than that of 1897.

On the other hand, it is noticeable, that the temperature in 1898 is much lower than in 1897. The curve in 1898 for  $7^{\circ}$  extends down to  $63^{\circ}40'$  N. and  $7^{\circ}$  W., and along the entire route no temperature of

more than  $12^{\circ}$  is found, until quite in the North Sea. In 1897, the  $7^{\circ}$  curve did not reach farther towards the south-east than to about  $64^{\circ} 30' N.$  and  $8^{\circ} W.$

The observations of temperature and salinity instituted by *Wandel* in 1897, on Icelandic and Greenland steamer routes, are, as a rule, taken a little more to the south, and have thus rarely met the east Icelandic polar current. These observations also show that the surface-temperature in the southern part of the North Atlantic Ocean between the Shetland Isles and the Faroe Isles, was about  $1^{\circ}$  lower in July of 1898, than in that of 1897. In 1897 it was  $12$  or  $13^{\circ} C.$ , in 1898  $10.5^{\circ}$  or  $11.5^{\circ} C.$  (*Wandel & Ostenfeld* [98], Pl. I, *Martin Knudsen & Ostenfeld* [99] Pl II).

Thus in July, the polar current both in 1897 and 1898, reached farthest towards the east in from  $63$  to  $65^{\circ} N.$  Lat., as in 1896. This was also the case in March and May, 1897 and 1898; in March, 1898, and possibly in 1897, it reached so far that it overflowed the Gulf Stream for a short distance in about  $65^{\circ} N.$  Lat. On the other hand, all observations in winter and summer show a high salinity and temperature at the beginning of the North Sea about the Shetland Isles. Here the Gulf Stream with its great volumes of water, forces its way towards the north-east; and it is hardly conceivable that the polar current would be able to break its way across it into the North Sea.

According to observations hitherto made, it seems that the polar current and the Gulf Stream meet in the summer, farther north. The polar current moves in a south-easterly direction and the Gulf Stream towards the north-east.

Little has been ascertained about the result of this collision; but we know, that

- (1) In the direction of the Gulf Stream a current continues towards the north-east, of which the salinity is considerably less ( $35.0-35.3$ ) than that of the Gulf Stream off the northern extremity of Scotland, but which has nevertheless on the whole retained its *Atlantic* character.
- (2) The surface-currents along the coast of Norway generally flow towards the N. and N. E.
- (3) The surface-currents along the east coast of Scotland and England flow in a southerly direction.

- (4) In the northern part of the North Sea there are always large volumes of water, of which the salinity exceeds 35 ‰, and which is therefore water of Atlantic origin.

The *direction* of the Gulf Stream is thus almost exactly followed by its continuance in the North Atlantic, and by the coast currents along the north of Norway.

On the other hand, the direction of the current in the north-western part of the North Sea, corresponds rather with that of the east Iceland polar current.

It does not, however, follow that the *water* of the polar current moves southwards, and that of the Gulf Stream in a north-easterly direction.

It is quite as likely that on meeting, the currents intermingle, so that both the northward and southward-flowing water will consist of both Arctic and Atlantic water. Neither the Atlantic water covering the surface of the North Atlantic, nor the waters of the northern part of the North Sea have such a high salinity as the Gulf Stream to the west of Scotland. But as a rule, the salinity in the northern part of the North Sea is higher than in the Gulf Stream north of the Shetland Isles, e. g. in March, 1897, as will be seen from our surface-map and the accompanying tables (*Hjort & Gran* [99], Pl. 3, and Tab. B III, IV).

This would therefore seem to indicate, that the Atlantic water entering the North Sea, is more unadulterated than that which continues northwards, or that the greater part of the east Icelandic polar current must unite with the northern branch of the Gulf Stream, and move in an easterly direction parallel with the coast of Norway. There are also other circumstances which indicate this.

The direction of the polar current, as may be seen on *Pettersson's* sketch-map, is straight towards Stadt. At this promontory, the Norwegian coast turns towards the east, and the boundary between the west and north of Norway is placed here. Biologically, too, Stadt forms a clearly marked boundary. Many northern organisms have their southern limit just here, and southern organisms their northern limit. This is even the case with plankton organisms. As I shall relate at greater length in the next section, a community of coast plankton lives north of Stadt in the months of March and April, which agrees species for species with the Greenland and Spitsbergen coast plankton, while it is very different from that on the west coast of Norway.

On the west coast of Norway, south of Stadt, are found almost the same species as elsewhere in the North Sea and the Skagerrak; but many of these species are absent farther north, and others are found in their place that otherwise are only found on arctic shores. It must not therefore necessarily be supposed that this plankton flora comes in to the coast from arctic regions every winter, for instance, by the flowing of the east Icelandic polar current over the Gulf Stream, as in March, 1898.

As they are neritic species that are only found close to the shore, and as they all possess the faculty of forming spores, I think it very probable that they are stationary, but dwell, during the greater part of the year, at the bottom of the sea, in the form of spores.

Since, however, the ocean fauna and flora north of Stadt have an arctic character, while south of that promontory, they are Atlantic, it is *a priori* probable that the hydrographic conditions in the former case are more arctic than on the west coast south of Stadt.

This also indicates, that at any rate the main body of the east Icelandic polar current *does not come south of Stadt*, but moves in a northerly direction with the northern branch of the Gulf Stream.

This theory agrees, moreover, with the current-map of the North Atlantic, which *Mohn* [87] drew from theoretical calculations (l. c. Pl. XIV). It is also confirmed by the current-bottles that *Wandel* [98, 99] threw out on the Ingolf Expedition, between Jan Mayen and the north of Iceland. Twenty floaters were thrown out, of 14 of which reports have come in. Nine of them drifted ashore on the coast of Norway, one on the Murman Coast, the rest on the Faroe Isles or Iceland.

Those that came to Norway were all found north of Stadt, one at Bud in the Romsdal, immediately to the north of Stadt, the others in Nordland and Finmarken. *Wandel* also says ([98] p. 19): »As the table shows, the drift of the bottles is on the whole a confirmation of the eddy in the North Atlantic demonstrated by *Mohn*.»

## 2. Plankton Investigations in 1898.

The distribution of the plankton in the Northern Atlantic in 1898, is more fully known than it has ever been before, through the careful investigations of *Cleve* [99, 1, 2, 3] and *Ostenfeld* [99].

Two series of plankton-samples, however, collected in 1898 in the North Atlantic at the instigation of the directors of the Norwegian deep-sea investigations form a by no means unimportant supplement to the Swedish and Danish investigations.

The contents of the first series is given on Table I. Only the vegetable plankton has been examined; the animal plankton was, as a whole, poor.

The samples were taken in May on the »Heimdal's» cruise from Bergen to the Arctic Ocean. The table clearly shows that the character of the plankton is determined by the hydrographic conditions.

Stations I—III are taken in the coast currents off the west coast of Norway; the salinity is less than 35 ‰. At Station I, the salinity on the surface is only 33.02 ‰; the plankton is rich in Peridinia. *Ceratium tripos*, with the variety *longipes*, being specially numerous. This sample corresponds closely with the type *Longipes-plankton*, that is also to be found in the first half of the summer on the coasts of Nordland.

Stations II and III have a different character; it is no longer the Peridinia that predominate, but *Phæocystis Pouchetii*, and moreover, at Station II, the diatom *Leptocylindrus danicus*. *Phæocystis*, at any rate, has been very common for some years along the west and north-west coasts of Norway, from March to May. On the west coast, it occurred in March and April, 1898, in such large quantities, that it stopped up the nets so that they could scarcely filter the sea-water. The history of its development and its distribution is not yet sufficiently known to allow of a determination as to whether it is oceanic or neritic. It seems, however, to keep especially to the coasts. According to *Ostenfeld* it is found in particularly large quantities off the Faroe Isles; *Cleve*, in his last great work [99,1] refers it to the *Chæto-plankton*. *Leptocylindrus danicus* also keeps mostly to the coasts, but in its case also, it is doubtful whether it is a true neritic species. It is found in great quantities only in the Skagerrak and the Christiania Fiord (cfr. *C. G. Joh. Petersen* [98], *Hjort & Gran* [99], *Cleve* [97]). *Cleve* found it in abundance in a sample taken N. of Stadt in May, 1898. I have often found it on the coast of Nordland, but always rather scarce.

As far as I am aware, it is not met with west of Scotland. Its centre of distribution thus seems to be the Skagerrak, whence it may follow the coast currents along the shores of Norway. Its occurrence in this series also corresponds with this.

Stations IV—VII are in the body of the Gulf Stream. The plankton samples taken here are rather homogeneous, consisting for the most part of diatoms, with *Chaetoceras decipiens* as the characteristic form. It is the same plankton as that found in the same place in May, 1896; but it was still more abundant then. In 1897, even in the middle of May, it was very slightly developed. The inferior component parts are also the same as in 1896 (*Chaetoceras constrictum*, *cinctum*).

The plankton agrees very well with Cleve's type, *Chæto-plankton*, which in May is thus characteristic of the Gulf Stream to the north of the Shetland Isles.

It is moreover interesting to note, that the abundance of chæto-plankton in the three years, 1896—98 is proportional with the extent and temperature of the Gulf Stream; the year 1898 comes between the two preceding years with reference to the development of the plankton, as also in hydrographic respects. There is thus, as might be expected, a close connection between the hydrographic conditions and the development of the plankton.

After Station VII, there is unfortunately a blank in the plankton series, as the weather was so stormy, that even plankton samples could not be taken. The last stations (X—XIII) are all taken in the water of the polar current. In the two preceding years, even in May, they were very deficient in vegetable plankton; the samples contained only a few specimens of *Calanus hyperboreus* and *Calanus finmarchicus* (cfr. Nordgaard [99] Tab. 3).

The samples obtained in 1898 from the sealing territory, contained enormous quantities of diatoms, especially *Chaetoceras criophilum*, and, as inferior component parts of the flora, *Rhizosolenia semispina*, *Rh. obtusa* and *Chaetoceras atlanticum*. This plankton is so characteristic, that it can hardly be classed under any of Cleve's types. It comes perhaps nearest to the *Tricho-plankton*, with which it also corresponds most nearly from a biological point of view. The character alga however, *Thalassiothrix longissima*, occurs exceedingly rarely. The samples correspond closely with Ostenfeld's type 4, »the diatom plankton of the Irminger Sea« (Ostenfeld [99], p. 85), which he found in May and June »along the extreme margin of the East Greenland polar current from Denmark Strait, past Cape Farewell to the southern end of Davis Strait«. Ostenfeld's samples were taken farther south than mine.

Some of them, which have lived in a somewhat higher temperature (up to 9°) show transitions to the typical Tricho-plankton. The development of this characteristic plankton may be traced on Table 2, which shows the contents of a series of samples collected by Capt. L. Tufte between April and June, 1898, on the sealing-ground between Iceland and Jan Mayen.

The first three samples which were taken N. E. of Jan Mayen, are very poor; but the sample of April 29th already shows an abundant plankton, consisting for the most part of *Coscinodiscus*; this and the next succeeding samples correspond with *Ostenfeld's* «oceanic winter plankton», which I have moreover termed *Disco-plankton*. *Chaetoceras criophilum*, *atlanticum* and the *Rhizosolenia* species are however represented even here; and they increase in number. A few neritic species appear moreover — *Thalassiosira hyalina* (arctic) and *Chaetoceras debile* (arctic and sub-arctic).

From the 7th to the 16th May, the plankton is again somewhat poorer; the ship had come so far to the S. E., that she was outside the distribution-centre of the plankton community; but in all the last samples there are immense quantities of *Chaetoceras criophilum*, and the *Coscinodiscus* species gradually disappear. As will be seen from the temperature observations, all these plankton samples have been taken in *arctic* water, sometimes between ice-floes. Generally the oceanic diatoms develop in large quantities only in Atlantic water, or rather on the boundary between the waters of the Gulf Stream and the polar current.

It is also a very peculiar fact, that *Globigerina bulloides* occurs so regularly, and in no inconsiderable quantities, in such a low temperature (and salinity).

## II. The Coast-Waters of Nordland

### I. Hydrographic Investigations.

The first information regarding the hydrographic conditions of the coast of Nordland, was published in the report of the Norwegian North Atlantic Expedition, by *Mohn* [87] and *Tornøe* [80].

The results show that the salinity on the surface along the coast is less than out in the open North Atlantic, but on the whole, greater than along the south and west coasts of Norway. *Tornøe* (l. c. p. 68) states that «this dilution of the surface-water on all parts of the Norwegian coast is not anywhere found to exert a material influence on the surface-temperature. The decrease in the amount of salt must be obviously ascribed to the influx of river-water, the temperature of which during the summer months is relatively high — so high indeed, that the principal coastal current, flowing along the western shores of Norway, has a somewhat higher surface-temperature than that observed in its immediate vicinity».

*Mohn* further showed that the bottom-temperature everywhere upon the coast-banks off Nordland and in the deep fiords was high, often 5 or 6 degrees, while out in the North Atlantic, ice-cold water is found along the bottom. In the West Fiord, the water on the bottom had a temperature of more than 6°, but in mid-water, at a depth of from 40 to 60 fathoms, a minimum temperature of 4.5° was found in the summer. *Mohn* also gives two very important series of temperature-observations from Lødingen at the head of the West Fiord, in 1889—90 (l. c. p. 91), from which it appears that the temperature at the depth of 100 fathoms is almost constant all the year round — 6.3° to 6.5°.

*Gade* [94] has since published a report on the temperatures in the West Fiord during the Lofoten fisheries in 1891—92. The results show, on the whole, that at this time of year, there are two essentially different strata of water on the fishing-banks; at the top there is cold water to a depth of about 40 fathoms, its temperature in January being  $4^{\circ}$  or  $5^{\circ}$ , in February and March,  $2^{\circ}$ — $4^{\circ}$ . At a greater depth, however, comparatively warmer water was found, generally with a temperature of  $6^{\circ}$  or  $7^{\circ}$ . The boundary between these two layers is as a rule distinct, the temperature curves for  $4^{\circ}$ ,  $5^{\circ}$  and  $6^{\circ}$  lying close to one another; but as a result of the currents, this boundary is found at different depths at different times.

*Gade* also found that the amount of warmth in the water may be different in different winters. In the West Fiord, in 1892, great volumes of water were found with a temperature of more than  $7^{\circ}$ , of which there had been no trace in 1891. The maximum temperature was generally found about 60 or 70 fathoms below the surface. At greater depths, the temperature had again decreased.

Hydrographic investigations were subsequently made off the Nordland coast in the summer of 1895, by *Hjort*, and in the winter of 1896—97, by *Nordgaard*. The results have been published in two papers by *Hjort & Gran* [99], and by *Nordgaard* [99]. These investigations show that the salinity is less throughout in the winter than in the summer (cf. *Hjort & Gran*, l. c. Pl. 7, figs. 1 a, b). In the summer of 1895, *Hjort* found that the curve for  $35\text{‰}$  salinity went up to from 50 to 70 metres below the surface, even in the West Fiord. Above this, the salinity was rather less, but still fairly great; and it was only in shallow strata close to the shore that it was less than  $34\text{‰}$ . In March, 1896, on the other hand, the coast-banks were covered with water of  $34\text{‰}$  salinity, and the Atlantic water of more than  $35\text{‰}$  was not found until depths of more than 150 metres below the surface. In the West Fiord, moreover, there were found rather extensive layers of cold water with a salinity of 33 and  $34\text{‰}$ ; these layers might descend to a depth of more than 100 metres.

These investigations of *Nordgaard's* are especially interesting from the light they throw upon *Gade's* results. The volumes of cold water that *Gade* found, correspond to the coast-water with a salinity of from 32 to  $34\text{‰}$ , while the warmer water with a temperature of up to  $7^{\circ}$  and more, is  $34\text{‰}$  water, that has stood in the fiord depths from the autumn.

The reason why the boundary between the strata of water may be so clearly defined as *Gade* and *Nordgaard* found it to be, is evidently that the winter's cold produces vertical circulation in the upper layers, when the surface-water cools down. The circulation cannot, however, extend down through the 34 ‰ salt water with its higher specific gravity; this therefore retains its high temperature, while the coast-water gradually cools down from 4.5 ° to about 2 °.

The temperatures taken by *Hjort* in July and August, 1895, agree on the whole with *Mohn's* results; at a depth of 80 metres, a minimum temperature of as little as 4.3 ° was found in July.

My own investigations in the summer and autumn of 1898 and 1899, were made with the object of acquiring a more thorough knowledge of the annual variations in the hydrographic conditions, and especially of finding out whether there were any difference from year to year.

After a few tentative investigations, I chose Eids Fiord in Vesteraalen, with its surroundings, as my special field of investigation. It was desirable to limit the ground examined, and the Eids Fiord was an especially favorable place, as this famous herring-fiord lies directly facing the ocean at a place where the Vesteraalen edge goes close in to shore. There was therefore an opportunity, even with the limited means at my disposal, of obtaining connected series of observations from the very head of the fiord right out over the Vesteraalen edge.

Like most of our fiords, the upper part of Eids Fiord is very deep. Abreast of Kvalsøen, at the hydrographic station E<sub>2</sub>, the depth is over 230 metres. The fiord is shallower at its mouth; but the bar which shuts off the inner basin from the depth outside, is scarcely anywhere less than 100 m. below the surface. Outside the fiord itself, in the sound between Bø church and Hadseløen, there is another depression, whose deepest part forms an enclosed hollow; its depth is more than 200 m., while all round it is scarcely more than 150 metres. I have here placed the hydrographic station E<sub>3</sub>. The next station, E<sub>4</sub>, lies just outside the belt of islands, 4 miles to the west of Gaukværø. Here too, the depth is more than 200 metres, as there is a small depression in the coast-banks, which are elsewhere from 100 to 150 metres below the surface. E<sub>5</sub> lies in the middle of the banks, near a well-known fishing-ground — «Skallen», and E<sub>6</sub> is just off the Vesteraalen edge, which is here 30 or 40 miles from land.

The results of the investigations will be found in the hydrographic tables, pp. XXX—XXXVIII. The salinity of the water is great and very uniform; both in the summer and autumn, the fiord was filled with water with a salinity of 34—35 ‰ and the layers of water moving over the coast-banks are also, for the most part, within the same limits of salinity. Only out by the edge is the Atlantic water with more than 35 ‰ salt found up to 30 or 40 metres below the surface; and upon the banks themselves, it seems to cover the bottom from a depth of about 150 metres.

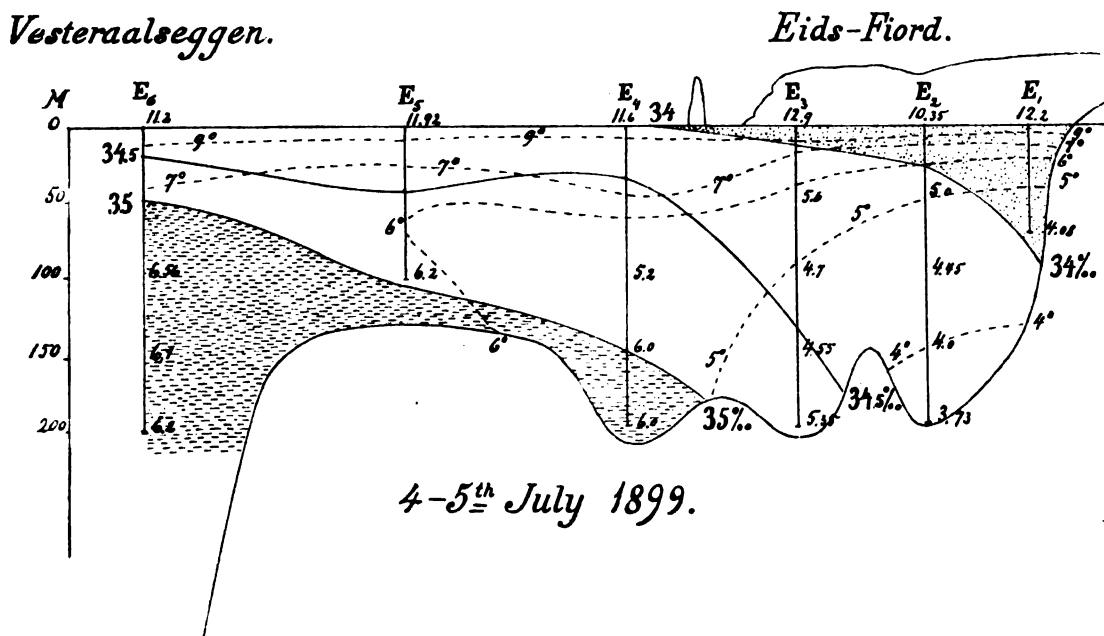


Fig. 1. Section from the Vesteraalen edge to the Eids Fiord.

Coast-water of less salinity than 34 ‰ is rarely found; only at the very head of the fiord did it occasionally in the spring form deep layers. The lowest observed salinity was 32.24 ‰. The temperature, on the other hand, varies much more than the salinity.

During the first few days of July, 1899, a series of observations were made from Eids Fiord to the Vesteraalen edge, as will be seen from the hydrographic tables III a, p. XXXV, and in the accompanying fig. 1. The salinity throughout is between 34 and 35 ‰; out on the edge, there is 35 ‰ water from a depth of 40 metres downwards, and a little was also observed deep down at Station E4. Water with 33 ‰

salt was found on the surface from Station E<sub>5</sub> inwards; and at the innermost station, E<sub>1</sub>, abreast of Sildpollen, it goes to the very bottom, to a depth of 70 metres.

The distribution of temperature is very peculiar. The summer warmth has not yet penetrated to any great depth; even at a depth of 10 metres, the temperature is generally under 10°. But out on the edge, the water is comparatively warm, and the lowest observed temperature here is 6.1°, at a depth of 150 metres. Farther in towards the land, the water is generally colder. The lowest temperature observed is:

At Station	E <sub>5</sub>	6.00 °,	depth	50 metres.
- —	E <sub>4</sub>	5.20 °,	» 100	—
- —	E <sub>3</sub>	4.38 °,	» 120	—
- —	E <sub>2</sub>	3.73 °,	» 200	—
- —	E <sub>1</sub>	4.08 °,	» 70	— (bottom)

The minimum temperature thus becomes lower throughout with the increasing proximity to land, and it is found at greater and greater depths, until, at the head of the fiord, it is on the bottom. In other words, in the fiord there are great quantities of cold water, that must have been lying there from the winter and spring, while out on the banks,

warmer water has flowed in. This is a phenomenon with which we are also acquainted in other fiords, e. g. Gullmare Fiord in Sweden (*Pettersson & Ekman* [91]), and in the Christiania Fiord and others in southern Norway (*Hjort & Gran* [00]). In the fiords that have great basins in their upper part, much deeper than the lower part, it is especially the deeper volumes of water that stagnate, because the bar at the mouth of the fiord cuts them off from direct communication with the ocean outside. It will be seen, however, that the cold water in Eids Fiord is not only found in the deep, shut-off basin. In the upper part of the fiord, the curve for 5° goes up to 40 or 50 metres below the surface. The explanation of this circumstance is that even the upper strata in the fiord are only slowly carried away by the currents which bear the warmer water northwards.

The cold water in the fiord possesses a very abundant and characteristic northern plankton, consisting of *Calanus finmarchicus*, *C. hyperboreus*, *Spadella hamata*, Ctenophora and a few northern Peridinia (*Longipes-plankton*). Outside the fiord, the plankton has a more southern character.

The coast currents seem to be most powerful on one side quite out on the edge ( $E_6$ ), and on the other side just outside the belt of islands ( $E_4$ ). At these two places, the temperature-curves turn somewhat downwards, and there are greater volumes of heated water than in the middle of the coast-banks and in the fiord. This is still more evident from the series of observations that were taken later in the summer.

On July 24th and 25th, the conditions have changed somewhat, as will be seen from the hydrographic tables on pages XXXVI & XXXVII. It is true there is still a considerable quantity of cold water in the fiord,

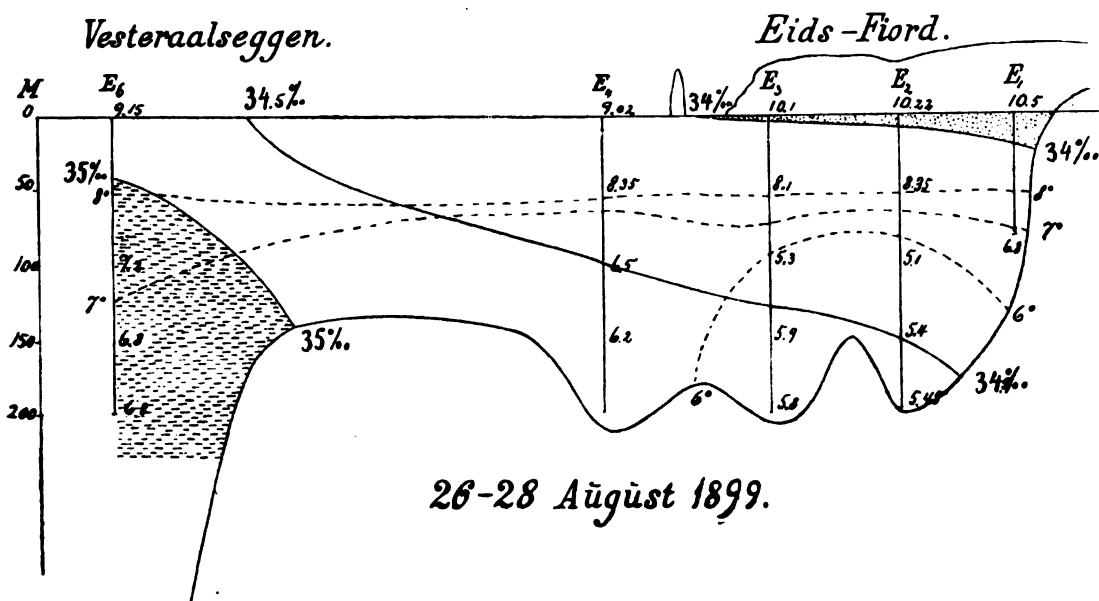


Fig 2

but less than there was 3 weeks earlier. The minimum temperature at Station  $E_2$  is no longer on the bottom, but at a depth of 100 metres; and at a depth of 200 metres, the temperature has risen from  $3.73^\circ$  to  $5.35^\circ$ , and the salinity from  $34.19\text{‰}$  to  $34.64\text{‰}$ . Considerable volumes of water have thus flowed in along the bottom of the fiord; and the same temperature and salinity that is now found at a depth of 200 metres in the middle of the fiord ( $E_3$ ), was found 3 weeks earlier at the mouth of the fiord ( $E_6$ ), at the same depth. At the mouth too, the salinity at the bottom has increased (from  $34.64$  to  $34.83\text{‰}$ ). The volumes of cold water must have been forced upwards and outwards; a

tendency towards a movement of this kind is already visible in the direction of the temperature-curves on the 4th and 5th July (fig. 1).

The plankton in the fiord still has a northern character, but in actual numbers is much less than 3 weeks previously. There is no doubt whatever that a large proportion of the northern organisms have moved out with the cold strata of water.

The next connected series of observations were taken between the 26th, and 28th August (see fig. 2 and p. XXXVIII). In the north of Norway, August, 1899, was a cold month, with much bad weather and violent south-westerly storms. This was probably the reason of the comparatively low surface-temperature out on the coast-banks. The temperature on the surface has fallen since the last investigation, but the total amount of heat in the water has nevertheless considerably increased; the temperature curve for  $8^{\circ}$  lies throughout at a depth of 50 metres, or even deeper. Out on the edge, there are numerous oceanic organisms of southern origin. In the fiord there is still a minimum temperature at a depth of 100 metres; the lowest temperature is now  $5.1^{\circ}$  as against  $4.4^{\circ}$  in the preceding month. At a greater depth than 100 metres, however, the situation is to a certain extent unchanged, both as regards temperature and salinity, and no fresh inflow seems to have taken place along the bottom.

The surface strata, on the other hand, have changed their character. The salinity has diminished, and the amount of heat has increased; and the plankton has a more southern character. The heated surface-layers in the shore-currents appear to have forced their way into the fiord, and to have remained there for a time, while colder water has taken their place out upon the banks.

In 1898, two series of observations were taken in Eids Fiord which may supplement the results of 1899. On the 29th and 30th July, the fiord was examined from Station Es upwards, as will be seen from the tables on p. XXX, and on Pl. II, fig. 3. The conditions correspond, on the whole, with those found in 1899 at about the same time (July 24 & 25).

The second series of observations, taken on the 22nd and 23rd September (pp. XXX & XXXI and Pl. II, fig. 4), shows greater deviation from 1899. It will be seen that the temperatures in September, 1898, are on the whole as high as, or higher than, those in August, 1899.

The heated volumes of water often extend to a great depth, greatest of all just outside the belt of islands, where I found  $9.9^{\circ}$  down to a depth of 100 metres. In the fiord, the salinity at the bottom is great ( $34.89$  ‰ or more), and the temperature above  $6^{\circ}$ ; nor is any minimum temperature of less than  $6^{\circ}$  found at any other depth. The cold water of the winter is thus now completely driven out. On the other hand, there is now in the fiord a maximum temperature ( $10.33^{\circ}$  at a depth of 30 metres) that is a remnant of the summer, while outside the water is colder.

Later in the autumn, the temperature is gradually equalised. The water cools from the surface downwards, and the salinity is so uniform, that it cannot hinder the vertical circulation occasioned by the cooling down. Unfortunately the observations for the last three months of the year are very few in number, but the few there are indicate that there must be a strong vertical circulation, which equalises differences in both temperature and salinity, and gradually produces the uniform layer of cold water, that is known through *Gade's* and *Nordgaard's* investigations. This uniform layer does not, however, as a rule go to the very bottom; in the winter it rests upon a warmer stratum, of which the salinity is too great to allow of the vertical circulation penetrating farther down than to its uppermost limit, and the temperature as a rule is above  $6^{\circ}$ .

The remaining investigations made in the West Fiord, in Tys Fiord and Ofoten, on the whole confirm the general rules that may be deduced from the observations in Eids Fiord. I shall therefore not describe the results in detail, but refer to the tables (pp. XXV—XXIX). I will here only lay stress upon the fact that in the early part of the summer in the West Fiord also, there is a minimum temperature at a depth of 80—120 metres, of less than  $6^{\circ}$ , as *Mohn* also found. At a depth of 200 metres, on the other hand, the temperature was always  $6^{\circ}$  or more. In this circumstance, the wide, funnel-shaped West Fiord differs from the Eids Fiord, which is a typically narrow, groove-like fiord. As already mentioned, *Mohn* has also stated that the temperature in the West Fiord at a depth of 100 fathoms, remains at a little above  $6^{\circ}$  all the year round.

Table e, on page XXVIII, shows how the hydrographic changes take place in the upper strata among the islands in the belt, off Bodø. It will be seen that the heated surface-layers, containing comparatively little salt, are here fairly deep. On account of the current, and by the inter-

mingling of the layers of water, the heat of summer penetrates deeper than in the open sea, and deeper than in the fiords. The same circumstance is known in other places, e. g. the Skagerrak. In October, the cooling down and the vertical circulation have begun.

Is there any essential difference in the hydrographic conditions in different years? We still have too little material for the solution of this question. *Gade's* investigations show, however, that there were rather great differences between the winters of 1891 and 1892; but as investigations were not made at the same time out at sea, nothing can be said as to the reason of this difference.

The summers of 1898 and 1899 seem to have passed in a somewhat similar manner as regards hydrographic conditions. That of 1898, however, was considerably warmer, and the autumn came in the sea, in 1899, almost a month earlier than in 1898.

In the summer of 1895, according to *Hjort's* investigations, the salinity was greater throughout than in 1898—99. Atlantic water with a salinity of more than 35 ‰ was even found in the West Fiord (Stations 17—19) up to between 60 and 80 metres from the surface; and the temperatures at the same time were remarkably low, even less than 5 °. In 1898—99, I found nothing answering to this. Over the Vesteraalen edge, Atlantic water was found regularly from about 30 metres below the surface; but in the West Fiord, and on the coast-banks near the shore, the curve for 35 ‰ salinity never lay higher than 150 metres. I never, moreover, found Atlantic water with a lower temperature than 6 °.

It thus seems possible that, from a hydrographical point of view, there may be an essential difference between the various summers, and that the periodic development of the plankton may take a different course. But this circumstance must be examined into more closely. *Hjort* educes the rule, based upon his own and *Nordgaard's* investigations, that the Atlantic water rises much higher towards the coast in the summer than in the winter; but my investigations in 1898—99 show that the difference is at any rate not especially noticeable every year. This rule therefore,

does not appear to be so generally applicable on the coast of Nordland as farther south.

The general results of the hydrographic investigations may be summed up in the following manner:

1. The coast-banks off the coast of Nordland are covered in the summer and autumn by water of which the salinity is between 34 and 35 ‰. Water with a greater salinity is only found deep down, from 100 metres downwards. Out on the edge, however, where the banks slope down towards the depths of the North Atlantic, it goes almost up to the surface.

This water is in constant motion, principally in a northerly direction. In the summer, it carries with it southern organisms. The movement seems to be most marked out on the edge and in by the belt of islands, where the heated layers of water are generally deeper than in other places.

Where the water comes from cannot be decided on the basis of purely hydrographic researches. It is possible to imagine five chief sources that perhaps each, to a greater or less extent, assist in determining the character of the shore-water (1) the North Sea, especially the shore-current along the west coast of Norway, (2) the Gulf Stream, (3) the east Icelandic polar current, (4) fresh water from the coast itself, and (5) the shore-current from the north-east, from the Arctic Ocean (?).

The biological investigations here give a few hints, concerning which, see the last section of this paper.

2. The waters of the fiords are carried along with the movement of the shore water, but much more slowly than the latter. The cold water which collects in the fiords in the winter and spring, partly by being conveyed from without, partly by cooling down on the spot, remains far on into the summer, and produces a temperature-minimum of from 4 to 6° at a depth of about 100 metres, or even more. In the course of the autumn, this cold water is dislodged, partly by in-flowing currents along the bottom, partly by warm surface-currents. In the autumn a temperature maximum is gradually formed in the fiord by water left from the summer. This maximum may be perceptible all through the winter, as *Gade's*

investigations show\*. In the winter there are deep layers of water in the fiords, with a salinity of from 33 to 34 ‰.

3. The periodic changes in the hydrographic conditions of the coast-water do not take place in quite the same manner every year. The reason of these differences has not yet been explained.

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\*) *Nordgaard*, in a preliminary report [00], has recently described some fiords, which in winter are filled with cold water layers right to the bottom (e. g. Sjømen Fiord. Øgs Fiord).

## 2. Plankton Studies.

### Introduction.

Recent investigations of the organisms of the ocean have taken two essentially different directions.

German and English naturalists have taken up the various sides of the question raised by *Hensen*, as to the actual amount of organisms in the ocean, the ability of the various ocean territories to produce organic matter, and the general vital conditions of the organisms.

*Cleve*, and after him other Scandinavian investigators (*Aurivillius*, *Ostenfeld*, *C. G. Joh. Petersen*) have investigated the distribution of the plankton organisms mainly from this point of view, namely, that their occurrence can serve as a guide in determining the origin of the water-strata in which they live.

Both these branches of research, if the questions are to be solved, require a very great number of investigations to work upon. It is necessary to know the biological conditions of the various species; and one of the most important questions is how far the organisms can maintain life and multiply, while the water is moving and gradually changing its hydrographic character.

The various investigators have expressed themselves, with regard to this question, in various ways. *Cleve* has started by taking for granted that the character of the plankton is preserved during the movement of the ocean currents, and that when two ocean regions have the same plankton organisms, they must be connected by currents. In his latest works, however, he appears to have modified this view somewhat.

*C. G. Joh. Petersen* [98] has demonstrated, on the other hand, that the plankton of a flowing volume of water may be greatly changed

during its movement, even in very short distances, especially in the vicinity of the shore. *Schiitt* [92, 93] had also previously expressed the idea that confined ocean regions retain their characteristic plankton flora, although the water is in constant motion, and although the floras where the current comes from, and where it is flowing to, are quite different.

These and other similar questions cannot be settled until very thorough investigations have been made regarding the distribution of the plankton organisms at all seasons of the year. The numerous facts brought to light by investigations in the Skagerrak and the North Sea by *Cleve* [97, 99, 3, 00] and *Aurivillius* [98], and in the North Atlantic between Scotland, Iceland and Greenland by *Ostenfeld* [98, 99], are therefore of the greatest possible importance. Some of the samples examined were taken by steamers, which traverse long distances in a short time, so that almost simultaneous observations could be obtained over a wide extent of ocean. It has therefore been in some measure possible to construct charts of the distribution of the plankton on the surface at a given time.

But besides investigations of this kind over extensive regions, it is necessary to carry out systematic investigations of limited ocean areas, if possible at all seasons of the year. Such investigations are most conveniently carried on near the shore, and it is moreover especially important to understand clearly the relation between the plankton of the coast, and that of the open sea.

Have the various coast-waters each their stationary plankton, or are the numerous small organisms that directly or indirectly afford nourishment to our fish, only to be regarded as visitors from the open sea?

As I had undertaken to institute hydrographic biological investigations on the coast of Nordland during the summer-herring fisheries, I made it the principal aim of my efforts to bring a contribution to the solution of this last question. According to the now generally accepted view, based upon *G. O. Sars's* investigations, the summer-herring resorts to the coast in the summer and autumn to feed on the plankton that is then found in abundance on the coast-banks. This theory has not, indeed, been proved, but it is the only one that has hitherto been broached with good grounds. Whether it is correct or not, it will be interesting to investigate the conditions for the occurrence of the abundant coast-plankton.

One of the most important contributions towards the settlement of the question as to the relation between the pelagic fauna and flora on the coasts, and those in the open sea, is *Aurivillius's* detailed treatment of the subject of the plankton of the Skagerrak. He has examined the plankton at all times of the year, and compared samples taken outside the belt of islands, with samples from the islands and the fiords, compared the surface-plankton with the plankton of the deeper strata. He has arrived at the conclusion that the plankton organisms of the Skagerrak are partly *endogenetic* species, which remain there all the year round, partly *allogenic* species, which come in from other seas, the Baltic, the North Sea, or the Atlantic. The allogenic species are partly of southern, partly of northern origin, and *Aurivillius* has also put forward theories as to the ocean regions from which the several species probably come.

The dividing line between the allogenic and the endogenetic species is not, however, quite clear. The writer states, for instance, with regard to *Calanus finmarchicus*, that it is found in the open Skagerrak all the year round, both at the surface and deep down; in the fiords and on the coast it is only met with on the surface during the cold months (September to June), but all the year round in the deeper strata.

*Aurivillius* concludes, with reference to this and a few other species, that »ein geringes Procent gewisser Arten in tieferen Schichten fortlebt, vielleicht auch dort sich vermehrend, während dass aber deren Hauptmasse jährlich wieder von der Fremde aus herbeigeführt wird« (l. c. p. 19).

The allogenic species, which for the most part come from the open sea, constitute according to *Aurivillius*, a very large proportion of the total amount of plankton.

From my own investigations of Norwegian and Greenland plankton diatoms [97, 1, 2, 3], I came to the conclusion that these organisms may be most naturally divided into *holoplanktonic* species, which spend the whole period of their existence in a free-floating condition, and *meroplanktonic* species, which may or must go through a developmental stage on the bottom, generally in shallow water along the coasts. It naturally follows that the meroplanktonic species have their centre of distribution along the coasts, while though the holoplanktonic species are found most abundantly in the open sea, they can yet develop along the coasts.

The expressions «holoplanktonic» and «meroplanktonic» were introduced by *Häckel* [90]. He was also the first to distinguish between

*oceanic* and *neritic* species. The latter expressions have lately come into more general use, as they are shorter. The oceanic species correspond very closely with the holoplanktonic, and the neritic with the meroplanktonic; but the conceptions do not entirely coincide. It is quite possible, for instance, to imagine neritic species that are independent of the bottom throughout their existence, and are thus holoplanktonic.

The boundary between oceanic and neritic is much more difficult to fix, than that between holoplanktonic and meroplanktonic. There is a multitude of species that are found both in the ocean and along the coast. It is therefore to be regretted that the easier, but vaguer names have taken the place of the more exact expressions.

In employing, in the following pages, the same designations as other writers (*Cleve, Ostenfeld*), I will only remark that *all* the oceanic species are *independent of the bottom*, while *most* of the neritic species are connected with it at some period of their existence.

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Nordland, as indeed the whole coast of Norway, has been carefully investigated as regards Crustacea, by *G. O. Sars*; but except for this, there have hitherto been few systematic plankton investigations. In the summer of 1895, *Hjort* collected a number of samples, of which I have myself examined the botanical contents (*Hjort & Gran* [99], Tab. I). *Nordgaard* has also collected numerous plankton samples, especially from Lofoten in February, March and April, 1896 and 1897; the animals in these have been worked up by *Nordgaard* himself ([99], Tables 1—3), the plants by me (*Hjort & Gran* [99], Tables 5, 6 & 8).

After examining these samples, I came to the conclusion that the coast of Nordland was very deficient in neritic algæ, as compared with the shores of the Skagerrak and the North Sea. I tried to explain this by the fact that there is very little shallow water round the coast of Nordland, in which the meroplanktonic species can rest during unfavorable conditions (*Hjort & Gran*, l. c. pp. 15, 16). The sea was sometimes, nevertheless, fairly rich in plankton. The species of diatom that sometimes appeared in especially large numbers, was *Rhizosolenia alata*, and of Peridinia, *Ceratium tripos* with its varieties.

Plankton samples have moreover occasionally been collected on Swedish arctic expeditions also on the coast of Nordland. They are mentioned in *Cleve's* and *Aurivillius's* works

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As I wished to ascertain which species belong to the coast waters, and which come from without, my course of procedure was to investigate the distribution of the plankton by connected series of observations, from the fjords, and as far out from the coast as possible, and at various depths, just as in the hydrographic investigations. Observations of this kind were repeated during the time of the investigation as often as was considered necessary in order to see how the occurrence of the species varied in the course of the summer. In this way, a general view is obtained of the occurrence of the species in the summer and autumn, when the plankton contains the greatest abundance both of species and individuals.

From the winter and spring, in addition to *Nordgaard's* former investigations, I have only the samples that have been collected by private individuals all the year round on Herø in Helgeland, and at Røst in Lofoten.

Before going on to the general results, I will give a survey of the most important species, and state the manner in which, according to my own and previous investigations, they occur on the coast of Nordland.

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## **Bio-geographical survey of the most important species.**

### **Chlorophyceæ.**

*Halosphaera viridis*, Schmitz, is found all along the Norwegian coast, especially in the winter. It is probably distributed at any rate along the whole coast of Europe. Its developmental history is as yet imperfectly known. *Schmitz* has observed zoospores, and *Cleve* a kind of cyst-formation.

In Nordland it appears as early as the latter end of August in considerable quantities, and in September constitutes a large proportion of the plankton collected. It is found earliest at the stations farthest out,

subsequently near the shore, but not very numerous in the fiords. This should indicate that to some extent, at any rate, it comes in to the coast from without, and it may be regarded as certain that it is not a native of the fiords.

*Halosphæra* may be found on the coast of Nordland until late in April, perhaps even longer; it will easily escape notice in less perfectly preserved samples. It appears to have its maximum in the last 4 months of the year, a circumstance which gives it a peculiar position among the plankton organisms, as this season of the year is otherwise very deficient in plankton.

### Flagellata.

*Phæocystis Pouchetii*, (Har.) Lagh. appears along the coast at the time when the surface-water is at its minimum of temperature. It may often be found in great quantities, so that the colonies can easily be seen with the naked eye down in the sea, and so that with its mucilage it stops up the plankton nets. But its period of vegetation with us is a short one. In Nordland it is found from the middle of March to the end of May, with its maximum in April. According to *Cleve* [99, 1], it is also found off Spitsbergen in the hottest part of the summer.

It is not yet easy to decide where this organism has its distribution-centre. *Cleve* classes it with his type Chæto-plankton, thus making it an oceanic organism; but up to the present, at any rate, it has been found in greater quantities along the coasts than in the open sea.

### Bacillariales

Up to the present, there have been found no less than 50 different species of plankton diatoms on the coast of Nordland; but many of these are very rare, and only a very few appear in sufficient quantities to give their character to the plankton.

### Oceanic species,

Of these 50, 22 are oceanic, holoplanktonic species, which do not form spores, namely:

1. *Chaetoceras atlanticum*, Cl.
2. — *boreale*, Bail.
3. — *criophilum*, Castr.
4. — *decipiens*, Cl.

5. *Corethron hystrix*, Hensen.
6. *Coscinodiscus concinnus*, W. Sm.
7. — *oculus iridis*, Ehr.
8. — *radiatus*, Ehr.
9. — *stellaris*, Roper.
10. *Dactyliosolen mediterraneus*, Perag v. *tenuis*, Cl.
11. *Guinardia flaccida*, Perag.
12. *Nitzschia delicatissima*, Cl.
13. — *seriata*, Cl.
14. *Podosira subtilis*, Ostenf.
15. *Rhizosolenia alata*, Btw.
16. — *obtusa*, Hensen.
17. — *semispina*, Hensen.
18. — *Shrubsolei*, Cl.
19. — *Stolterfothii*, Perag.
20. — *styliformis*, Btw.
21. *Thalassiothrix Frauenfeldii*, Grun.
22. — *longissima*, Cl. & Grun.

The number is quite a large one; on the coast of Nordland, we find almost all the oceanic diatoms that are natives of the North Atlantic.

I will make a few brief remarks on each species, taking them in their alphabetical order.

1. *Chaetoceras atlanticum*, Cl., is a rare visitant on the coast of Nordland. I have only found it in a few samples from Øx Fiord in Finmark, in which *Rhizosolenia alata* predominated (Table VI), and in a sample that Nordgaard took in March, 1896, several miles outside Lofoten. It has, in addition to this, a wide distribution, so that no conclusion can be drawn as to whence it has come.

2. *Chaetoceras boreale*, Bail., is also surprisingly scarce in the north of Norway. While on the shores of the Skagerrak and the North Sea, it is so common that in longer hauls, at any rate, the net is scarcely ever taken up without finding a specimen of it, in Nordland it is rather rare. It appears to be more frequent a little farther out from the coast, and it may also occur in the fiords.

3. *Chaetoceras criophilum*, Castr., is seen much more frequently. In Eids Fiord it was found in considerable quantities during the first half of July, 1899; but the specimens were unusually small, and the chains were

to some extent broken up into single cells. Later in the summer (26th August), it disappeared almost entirely from the fiord, but vigorous specimens of it were then found out on the Edge («Vesteraalseggen»). In the Ofoten Fiord, which is very much deeper, it was still found in large quantities on the 28th July, but here too, narrow, stunted specimens. Although this species is an oceanic organism, it is still possible that certain members of it may remain in the deep fiord all the year round. In this way, it was found by *Nordgaard* at Liland in Ofoten, on the 24th February, 1897, and in several places in the West Fiord in the months of March and April.

4. *Chaetoceras decipiens*, Cl., is one of the most common diatoms on the coast of Nordland, and perhaps in the northern Atlantic as a whole. Out in the open sea, it sometimes appears in such great quantities that it forms an almost uniform «Chæto-plankton». Along the coast it occurs as a more or less subordinate constituent, but it is seldom altogether absent. It sometimes appears in abundance in the fiords in the spring, together with the preceding species; and when an abundant diatom plankton is found out on the banks, *Chaetoceras decipiens* appears as one of its principal component parts. It is found at all seasons. It is therefore probable that it stays both along the coast and in the fiords all the year round; but it is nevertheless quite possible that the stock may sometimes be replenished from without, though nothing can as yet be said with any certainty about this.

5. *Corethron hystrix*, Hensen, is found only in small quantities in Northern Norway, and especially at the outside stations. *Cleve* found it in oceanic samples as far north as Spitsbergen in the summer of 1898. He classes it with the Styli-plankton, and this agrees, too, with its appearance along the Norwegian coast. It must here then be looked upon as a visitant of southern origin.

6. *Coscinodiscus concinnus*, W. Sm., is found on the coast of Nordland all the year round, but only in small quantities.

7. *Coscinodiscus oculus iridis*, Ehr. is scarcely found in Nordland in the summer; but in the winter it is not uncommon. It constitutes an important part of the oceanic winter plankton (Disco-plankton), which has a very wide distribution in the northern Atlantic during the cold season.

8. *Coscinodiscus radiatus*, Ehr., may occur at all seasons of the year, but always in small numbers. It is most conspicuous in the winter, when it is found together with the preceding species.

9. *Coscinodiscus stellaris*, Roper, is not found in the summer, but in the winter it occurs together with the two preceding species as constituents of the scanty Disco-plankton.

10. *Dactyliosolen mediterraneus*, Castr. v. *tenuis*, Cl. This species has an occurrence on the coast of Nordland similar to that of *Corethron hystrix*. It is rare, and is generally found at the outermost stations, and especially during the warmest months, August and September. Like *Corethron* it must be regarded as a visitant from southern seas.

11. *Guinardia flaccida*, (Castr.) H. Perag., occurs in the same manner as the foregoing species.

12. *Nitzschia delicatissima*, Cl. This peculiar little diatom sometimes occurs in Northern Norway in enormous quantities, so much so that it quite imparts its character to the plankton. It appears to reach its maximum during the first half of July. It is not found at all in the fiords, or at any rate in very small numbers. It is most numerous in the belt of islands and just outside; farther out from the coast, it again decreases in quantity.

*Nitzschia delicatissima* is stated by *Ostenfeld* [99], p. 83, to be a characteristic form in the «oceanic spring plankton» which is found «in the North Atlantic from April to June, and in the Irminger Sea in August». *Cleve* had previously considered it as a characteristic form in the Tricho-plankton. In his latest work [99, 2] p. 806, he concludes from its occurrence in 1898, that it «belongs to the Irminger Sea, and spreads from the south of Iceland towards the Faroes and into Denmark Sound». In 1898, *Cleve* had not found it east of the Faroe Isles.

On the coast of Norway, it has previously (*Hjort* & *Gran* [99]) been found in great quantities by *Hjort* at Marstenen near Bergen on June 26th, 1895, and off Røst on July 9th, 1895\*, and by Capt. *S. Müller* outside Hustadviken in Nordmøre, June 13th, 1896. In 1898, it was found, moreover, in great quantities in the fiords in the province of Tromsø in October. and in 1899, at Røst and outside the Eids Fiord in July.

It is not probable that this alga is stationary on the coast of Nordland. There is much that goes to prove that it comes in to the coast

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\*) It was overlooked in the examination of this sample, and therefore not included in the table.

in May, when the oceanic spring plankton (Chæto-plankton) is not yet dislodged from the northern Atlantic by the warmer Styli-plankton. It may have remained and multiplied close to the shore for some little time beyond the spring, while at the same time more southern forms have already obtained the supremacy out on the banks.

13. *Nitzschia seriata*, Cl. (incl. *N. fraudulenta*, Cl.), is seldom absent where the foregoing species appears in large quantities. But it also occurs at various times of the year, seldom in any quantity, but nevertheless with tolerable regularity. It is therefore not improbable that at any rate certain individuals keep to the coast all the year round, in the same manner as *Chatoceras decipiens*, but in smaller numbers.

14. *Podosira subtilis*, Ostenf., I have found in a few samples, especially from the more distant stations outside Eids Fiord, in August and September. Judging from its occurrence in Nordland, it is of southern origin, and comes under the head of subordinate constituent parts of the Styli-plankton. This also agrees with *Ostenfeld's* statements.

15. *Rhizosolenia alata*, Brightw. (incl. var. *gracillima*, Cl.) appears on the coast of Nordland in greater quantities than any other diatom, probably, indeed, in greater numbers than any other organism. It is the characteristic form in the plankton, and in the warmest months (July—October) fills the sea upon the coast-banks. In July it appears in greatest abundance some miles from land; but in the latter half of August, it fills the sea right in to the belt of islands, while at the same time an active auxospore formation is going on. The species does not often go into the deeper fiords, however. I have only seen one exception to this, namely, when in October, 1898, it was found in great quantities in Øx Fiord in Finmark, where there was simultaneously an abundant influx of herring, while the herring-fisheries everywhere else were little short of failures.

*Rhizosolenia alata* is common along the whole coast of Norway, and in the Skagerrak and Kattegat right into the Baltic, where *Schütt* has investigated its auxospore formation. Through his investigations of the Skagerrak, *Cleve* [97] came to the conclusion that it belonged to the Tripos-plankton, the plankton of the Baltic current. In a later work [99, 1], he refers it to the Styli-plankton, that is to say the summer plankton of the Gulf Stream. The last theory agrees well with the appearance of the species on the coast of Nordland; it almost always occurs together

with *Rhizosolenia styliformis* and several other southern oceanic organisms, which have nothing to do with the Baltic current. But on the other hand, I have received the impression that *Rhizosolenia alata* is just a species that develops more numerous near the shore than out in the open sea, so that its wholesale appearance especially characterises the volumes of water, that in the summer flow over the coast-banks in the north of Norway.

16. *Rhizosolenia obtusa*, Hensen, is rare on the coast of Nordland. Its occurrence seems to be dependent upon very much the same conditions as *Nitzschia delicatissima*.

17. *Rhizosolenia semispina*, Hensen, is also rather rare. The same may be said with regard to its occurrence, as of that of the foregoing species. They are both classed by Cleve with the Tricho-plankton.

18. *Rhizosolenia Shrubsolei*, Cl., is a southern form that appears in company with *Rh. alata* and *Rh. styliformis*, in much smaller numbers than the first, but more abundantly than the second. Like them it comes in to the shore from outside, but it is capable of developing quite abundantly close to the shore in the summer. In the belt of islands off Herø, it is even more common than *Rh. alata*, which keeps farther out.

19. *Rhizosolenia Stolterfothii*, Perag, in its occurrence in Nordland, accompanies *Rh. styliformis* and *Rh. Shrubsolei*.

20. *Rhizosolenia styliformis*, Brightw., the characteristic form in Cleve's most clearly defined plankton community, Styli-plankton, is found regularly on the coast of Nordland from August to October, but as a rule in rather small numbers. It is found almost always together with great quantities of *Rh. alata*, its occurrence showing plainly that it is not stationary on the coast, but comes in with the ocean-currents.

21. *Thalassiosira Frauenfeldii*, Grun, is very irregular in its appearance, for which reason writers entertain various opinions as to the community to which it may most naturally be referred. Cleve originally classed it with the Tricho-plankton. In his latest work [99, 1], it is entered under northern neritic plankton, which in other respects he regards as «a peculiar kind of derived Tricho-plankton». Ostenfeld [99], p. 94, classes it among the eastern oceanic spring plankton, which almost corresponds with Cleve's Chæto-plankton.

It is rather rare on the coast of Nordland, but it may sometimes occur in great quantities. I have only seen it in samples that contained

an abundance of neritic diatoms. Both at Herø and Røst it is found in April in the abundant arctic diatom-plankton (Tab. XI, XII), and in October, 1898, it was found in large quantities in the fiords in the province of Tromsø, together with neritic autumn diatoms. It need not, however, on this account be neritic itself. *Chætoceras decipiens* and other oceanic species are also found in large quantities among the neritic species. The scanty observations hitherto obtained indicate that it is at any rate to some extent stationary on the coast, like *Chætoceras decipiens* and *Nitzschia seriata*.

22. *Thalassiothrix longissima*, Cl. & Grun. is very rare on the coast of Nordland. Only a very few specimens of it have been observed off Røst in March, 1896.

The plankton community that has taken its name from this alga, may therefore be said to be absent in the north of Norway. Some of the other characteristic forms mentioned by Cleve [99, 1], p. 7, are about equally rare (*Chætoceras atlanticum*, *Rhizosolenia obtusa*, *Rh. semispina*). Others, however, are exceedingly common (*Calanus finmarchicus*, *Cyttarocylis denticulata*, *Ptychocylis urnula*).

#### Neritic species.

The neritic diatoms of Nordland form two essentially different groups, one of which vegetates luxuriantly in the latter part of winter, in April, the other in the summer and still more the autumn.

The first group coincides very nearly with Cleve's *arctic neritic plankton* (Ng.), which, moreover, in his latest work, he has in a measure mixed up with the winter plankton of the Skagerrak (Sira-plankton); the second answers to his *northern neritic plankton* (Ns). These two communities have many species in common, indeed, most of the coast forms belong to both types. The communities however, are very different, as the species that are the characteristic forms in the one, constitute a very subordinate part of the other, and vice versa

In the following list of the several species, Cleve's symbols for indicating whether the species have their maximum in the winter in the arctic community (Ng), or in the autumn in the sub-arctic (Ns), are given before each specific name.

23. Ng. *Achnanthes teniata*, Grun. is a pronounced arctic form. It is found only rarely on the coast of Nordland, more especially in the winter.

24. Ng. *Biddulphia aurita*, Lyngb., is a species with a very wide distribution. It is not infrequently found as a littoral form among algæ and Bryozoa, e. g. in the Christiania Fiord and on Spitsbergen. As a plankton alga, it is a pronounced winter form both in northern Norway, and elsewhere along the North European coasts. I have seen samples from North Iceland taken in April, in which this species and the high-arctic *Melosira hyperborea* were the only plankton organisms. Cleve includes it in the Sira-plankton and the arctic neritic plankton.

25. Ns. *Cerataulina Bergonii*, H. Perag., occurs on the coast of Nordland only in the summer and autumn, not infrequently, but always in small quantities. It is far more common in southern waters, and should perhaps be regarded only as a visitant to Nordland.

26. Ns. *Chaetoceras constrictum*, Gran, is not common in Nordland. In southern Norway it has its maximum in April and May, but in Nordland I have only seen it in the summer and autumn. It is possible that it may then be carried northwards with the coast currents. Although it is emphatically neritic, it cannot be regarded as certain that it is stationary in the north of Norway.

27. Ns. Ng. *Chaetoceras contortum*, Schütt, is perhaps the commonest of all the neritic diatoms of Nordland. It is found in greatest abundance in the autumn, but is not missing among the arctic diatoms of the winter. It has also a very wide distribution, being found on the coasts of Greenland and Spitsbergen, on the New Siberian Islands (by *Nansen*) and its spores on ice-floes in the Polar Sea (cf. *Gran* [oo]). In our deep fiords, which are otherwise very deficient in neritic diatoms, it may be found, but not often.

28. Ns. *Chaetoceras coronatum*, Gran, is found by *Cleve* at Tromsø in June. I have not seen it from the north of Norway.

29. Ns. *Chaetoceras curvisetum*, Cl. is rather rare in the north of Norway, while in the south, it is one of the most common species. It is only found in the summer and autumn in Nordland: it is perhaps not stationary.

The most northerly point at which it is found is between Tromsø and Spitsbergen, in  $74^{\circ} 50'$  N. Lat. and  $16^{\circ} 37'$  E. Long., on May 29th, 1897 (by *Cleve*, published in the paper by *Pettersson & Ekman* [98], p. 49) It has not been found west of the Faroe Isles.

*Cleve* classes it among the *Didymus*-plankton, the neritic autumn plankton of the North Sea, where it predominates. Of the sub-arctic coast plankton it constitutes at any rate only a minor part.

30. Ng. Ns. *Chaetoceras debile*, Cl., is one of the commonest diatoms in the north of Norway. It sometimes appears in great numbers both in April and in September and October, in both cases equally numerous. Outside the Romsdal and the Trondhjem Fiord, it predominates in March and April. It is undoubtedly stationary.

This species seems to have its centre of distribution on the coasts of Northern Europe. Its spores, however, are also found off the New Siberian Islands, and on ice-floes in the Polar Sea, and it is sometimes found as plankton in East Greenland, while on the coast of West Greenland it is less frequently found.

31. Ng. Ns. *Chaetoceras diadema*, (Ehr.) Gran. The distribution of this species is nearly as great as that of *Ch. contortum*, but in its occurrence as plankton, it has a more northern character. At certain seasons, it is the characteristic form on the coast of Greenland (*Cleve* [96]).

In northern Norway, it seems to occur somewhat more abundantly in the winter than in the autumn. It undoubtedly belongs to the endogenetic plankton of the coast.

32. Ns. *Chaetoceras didymum*, Ehr. is rather rare in Nordland, though it is found somewhat more frequently than *Ch. curvisetum*. In its distribution otherwise, it is very much the same as that species.

33. Ng. *Chaetoceras furcellatum*, Bail., is a pronounced arctic form which, in Norway, is not found farther south than Stadt. In company with *Fragilaria oceanica*, *Lauderia fragilis*, *Navicula Vanhöffenii* and *Thalassiosira hyalina*, it characterises the winter plankton of northern Norway, as opposed to the plankton of the west and south coasts.

It is found in considerable quantities, though not nearly so abundant as off Greenland and Spitsbergen; it may also be found in the summer and autumn, but in rather small numbers.

34. Ns. *Chaetoceras lacinosum*, Schütt, is not uncommon in Nordland in the summer and autumn. It is one of the characteristic forms in the sub-arctic plankton which lives on the coast of northern Norway during the warmest season of the year.

It is rare in Nordland in the winter, but farther south it may be found at all seasons.

According to *Ostenfeld's* investigations [98 and 99], this species is found in great quantities in the middle of the Atlantic, between Scotland and the southern extremity of Greenland, from April to June, together with *Chaetoceras Willei*; but both species were more delicate here and less silicified than they are when they occur along the coast.

It is therefore with hesitation that *Ostenfeld* refers these oceanic forms to the corresponding neritic species. Judging from a sample that he kindly sent me, I conclude that he is right in referring them as he has done. In this case, they must be regarded as dwarf forms which develop in such a peculiar manner, because the species have drifted away from their natural abode along the coast. It is remarkable that these forms occur in such large quantities in the open sea, that they are the characteristic forms in the «oceanic spring plankton».

The closely-allied species, *Chaetoceras breve*, Schütt, which occurs rather frequently in the Skagerrak, I have not found in the north of Norway.

35. Ng. *Chaetoceras sociale*, Lauder, seems to be found only during the coldest season of the year in the north of Norway; but it may then appear in such large quantities as to constitute the greater part of the plankton (cf. Tab. XII). It is also found along the coast of Northern Europe, especially in the winter. It seems altogether to have a very wide distribution, as it is found both in the Arctic Ocean and at Hong-Kong.

36. Ns. Ng. *Chaetoceras teres*, Cl., is found on the coast of Nordland both in summer and winter, but never in especially great quantities. It therefore belongs, as a minor component part, to both the arctic and the sub-arctic neritic plankton. Its field of distribution appears to extend over about the same area as *Ch. diadema*, but it is not so plentiful.

37. Ns. *Chaetoceras tortissimum*, Gran, is a new, characteristic little species, of which a description will shortly appear in a paper in the «Nyt Magazin for Naturvidenskaberne», Vol. 38. It has only been found in the fiords north of Lofoten in October, 1898, but it is not rare. I have not found any spores, but its occurrence indicates that it is a neritic diatom.

38. Ns. *Chaetoceras Wighami*, Brightw., is a true coast form with a very wide distribution; but it always occurs in rather small numbers. I have only once found it in Nordland.

39. Ns. *Chaetoceras Willei*, Gran, is one of the characteristic forms in the sub-arctic autumn plankton on the coast of northern Norway. It is almost always found together with *Ch. laciniosum*. *Ch. Willei* is very nearly allied to *Ch. Schüttii*; in the north of Norway, forms are sometimes found that are still nearer to *Ch. Schüttii* than the one living on the west coast of Norway. But nevertheless the difference is sufficiently great to allow of their being kept apart; and as they have not the same geographical distribution, I consider that they ought to be separated as independent species.

40. Ng. Ns. *Coscinodiscus polychordus*, Gran, is an arctic form which vegetates in Nordland in greatest abundance during the cold season.

41. Ng. *Fragilaria oceanica*, Cl., is a characteristic form in the arctic-neritic plankton. In Nordland it is only found from March to May; it has its maximum in April, when it forms spores.

42. Ns. *Lauderia annulata*, Cl., may be found in the autumn, but not abundantly.

43. Ng. *Lauderia fragilis*, Gran, is a characteristic form in the arctic-neritic plankton. It is found in Nordland regularly in April, but in rather small quantities.

44. Ns. *Leptocylindrus danicus*, Cl. is rather rare in Nordland, and the specimens are generally smaller than in the Skagerrak and on the west coast, where it sometimes appears in great quantities. In the south of Norway it makes its appearance with *Chaetoceras constrictum*, their distribution centre being apparently the Kattegat, the Skagerrak and the North Sea. It is not found west of Scotland. Cleve has found it off Spitsbergen, but in small quantities. Both there and in the north of Norway, it ought perhaps to be regarded as a visitor from southern waters.

45. Ng. *Navicula Vanhöffeni*, Gran, appears in Nordland in April in the arctic-neritic plankton. I have not seen the nearly-allied species, *N. septentrionalis*, Oestr. in this country.

46. Ng. *Podosira glacialis*, Grun.,\* is found in the same manner as the preceding species.

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\* In a paper, published in *Nyt Magazin for Naturvidenskaberne*, B. 38, 1900, I have shown that this species is to be considered as a true *Lauderia* — *L. glacialis* (Grun.) Gran.

47. Ns. Ng. *Skeletonema costatum*, (Grev.) Cl., is perhaps the commonest of all neritic diatoms on the coast of Nordland. It can also live quite at the head of the fiords, where otherwise neritic diatoms are seldom met with; but the chains are then exceedingly thin and weak, so that apparently the alga does not live under favorable conditions.

It is also sometimes found in the winter plankton, but not so plentiful as in the summer.

48. Ng. *Thalassiosira gravida*, Cl., has a distribution almost similar to that of *Coscinodiscus polychordus*. In Nordland it is found in the greatest quantities in the winter, but it may also be met with in the plankton in the summer and autumn.

49. Ng. *Thalassiosira hyalina*, (Grun.) Gran, is a pronounced arctic form. It has the same distribution as *Lauderia fragilis*, *Fragilaria oceanica* and *Chaetoceras furcellatum*.

It may as a rule be known from *Th. gravida* by the circumstance that the cells lie close together in the chain, very much like the coins in a roll of money. There is only an interval here and there, where there is a long mucilage thread between them.

50. Ng. Ns. *Thalassiosira Nordenskiöldii*, Cl. has a wider distribution than the two preceding species. It seems, like them, to be found along all the shores of the Polar Sea; but it also goes farther south. In the North Sea and the Skagerrak, it often constitutes the greater part of the neritic winter plankton; and it is found right down in the Bay of Kiel (*Hensen*).

On the coast of Nordland, it has its maximum in April, but it may also be found at other seasons of the year. It is seldom altogether absent where there is an abundant neritic plankton, even at the warmest season of the year.

### Peridiniales.

It is a characteristic feature of diatoms that at certain seasons, especially spring and autumn, they may appear in immense quantities, while all the rest of the year they may be so scarce as easily to escape observation. This holds good both of the coast forms and the oceanic species.

The Peridinia seem, indeed, each to have their separate maximum at the time of year when the vital conditions are most favourable for them. But their occurrence is nevertheless much more regular. Single individuals of the more common forms may almost always be found

alive in a free-floating condition. Propagation does not appear to take place as rapidly as in the diatoms; but neither do they disappear so quickly from the plankton when the conditions of life become less favourable.

Most of our *Peridinia* have their maximum at the warmest time of the year, only a few in the early summer (May to July), all the others in the autumn, from August to October. During the winter, all the species decrease in number, but not sufficiently to prevent their forming, all through the winter, an important part of the scanty winter plankton. They appear to have their actual minimum at the time when the diatoms have their first maximum, and when the surface-temperature is lowest. This, in Nordland, is in April.

It is not easy to decide whether the *Peridinia* are to be regarded as oceanic or neritic. Their spore-formation is as yet little known; and it is not known whether they can go through the whole course of their development in a free-floating condition. As most of the species are to be found in great quantities far from land, it is probable that they are holoplanktonic organisms. But on the other hand, most of the species are found in the greatest numbers along the shores, where the heat of summer has greater influence than in the open sea. They occur on the Norwegian coast in such great quantities, that they must play an important part in the economy of the ocean. *Schütt's* account [93] also shows that the *Peridinia* appear in far greater quantities in the shallow, warm coast-water, than in the deep, open sea.

The question then arises, whether the abundant supply of *Peridinia* in the coast-waters can be replenished by multiplication when vital conditions become favorable for the species in question during the course of the year; or whether it is carried away by the current every year, or perhaps, practically speaking, dies out owing to the varying hydrographic conditions, so that it must continually be renewed by supply from without. The question might also be presented in *Aurivillius's* terms: Are the various species endogenetic, developed from individuals that have wintered in one form or another, or are they allogenetic?

As regards the Skagerrak, *Aurivillius*, in his great and important work, has come to the conclusion that most of the *Peridinia* are endogenetic. Out of the 23 species and varieties which he mentions, he considers 16 to be endogenetic, and 7 allogenetic. Four of the latter are of

southern origin, namely, *Ceratium tripos* var. *macroceros*, and var. *bucephala*, *Pyrophacus horologium* and *Dinophysis sphaerica*; while 3 are supposed to derive from the territory between the Gulf Stream and the coast-water on both sides of the North Atlantic, namely, *Peridinium divergens* var. *depressa*, *Peridinium ovatum* and *Ceratium tripos* var. *arctica* (including v. *longipes*).

Cleve, on the other hand [99, 1], classes (I include only the forms found on the coast of Nordland):

With the Styli-plankton,

*Ceratium furca*

« *lineatum*

*Diplopsalis lenticula*

*Gonyaulax polygramma*

*Peridinium divergens*

« ( « var.) *oblongum*;

With the Tripos-plankton,

*Ceratium furca*

« *fuscus*

« *tripos*

« « v. *macroceros*;

With the Tricho-plankton,

*Ceratium tripos* v. *arctica*;

With northern neritic plankton,

*Ceratium tripos* v. *longipes*

*Peridinium divergens* v. *depressa*.

Ostenfeld ([99] pp. 84—86) has 3 oceanic plankton communities in which the Peridinia play an important part, namely, the *oceanic summer plankton* with *Ceratium tripos*, type form and var. *scotica*, *C. fuscus*, *C. furca*, and *Peridinium divergens*, and the *northern peridinal plankton*, with *Ceratium tripos* v. *longipes*, *Peridinium divergens* v. *depressa*, *P. ovatum* and *P. pallidum*, and further, the *peridinal plankton of the Davis Strait*, with *Ceratium tripos* v. *arctica* as the characteristic form. The northern peridinal plankton probably belongs to the North Atlantic north and east of Iceland. In the region investigated by Ostenfeld «it is met with where the northerly currents make their appearance, for instance, due east of the Faroe Isles, and between the Faroe Isles and Iceland with the east Icelandic polar current, and also in Denmark Sound in the east Greenland polar current.»

All the three above-mentioned authors agree in considering that *Ceratium tripos* v. *longipes*, *Peridinium divergens* v. *depressa*, and *Peridinium ovatum*, are northern forms, and of the others, some to be southern oceanic species, some coast-forms.

The occurrence of the species on the coast of Nordland, moreover, accords with this assumption. The three above-named forms have their maximum in May and June, before the heat of summer has had any influence on the water. Only in the deep fiords do they remain far on into the summer. The remaining species appear in the greatest quantities in the summer and autumn, *Ceratium tripos* v. *bucephala* being somewhat later than the others.

From this alone it appears that the fiords receive their southern forms — the greater part of their autumn plankton — from outside. It is another question whether the northern forms have also come in from the coast-water, or whether they have perhaps remained in the fiords all the year through. This question cannot at present be decided. *Nordgaard's* investigations ([99] p. 28) show that *Peridinia* are found in the fiords even in February and March, and the northern forms predominate, especially *Ceratium tripos* v. *longipes*; but it is not impossible that a new influx may take place in the spring.

But even if the fiords also receive the greater part of their plankton from without, the coast-water may still have its endogenetic plankton, with a more or less neritic character. It is a characteristic feature of our deep fiords that they are almost entirely destitute of endogenetic plankton; but the belt of islands and the banks outside ought to be better adapted for maintaining stationary communities of organisms.

Owing to the currents and intermingling, the heat of summer may here penetrate deeper than in the fiords and in the open sea; and there are at any rate some shallow parts, where the heated water may enter into reciprocal action with the bottom.

But all these conditions are too complicated to allow of the definitive solution of the question as to which organisms belong to the coast-water, and which come as visitors either from southern shores, or from the open sea. In the following list, I shall emphasise in the case of each form, what is known up to the present about their occurrence on the coast of Nordland; and for the sake of comparison I have added information from *Aurivillius* [98], *Cleve* [97, 99, 1, 00, 1—2] and *Ostenfeld* [98,

99], as to their occurrence in other regions. Unfortunately, a few forms have only so lately been distinguished from nearly-allied species, that the working-up is incomplete as far as they are concerned; and throughout I have examined the smaller forms less carefully than the larger ones.

*Ceratium tripos*, Duj. type form.

Is found in Nordland all the year round, perhaps with the exception of the months April and May. In the few samples that I have obtained from Herø (Tab. XI, XII) and Røst (Tab. XIII) by private assistance, it is absent during these months; but it may nevertheless occur, at any rate singly. It seems to have its maximum from August to November; and it appears, as a rule, that it is found in greater quantities in and outside the belt of islands, than in the fiords.

The manner in which this species occurs gives rise to the impression that it certainly remains all the year in small quantities along the coast; but the great number of individuals found at the warmest season of the year, must in a great measure come from the south with the coast currents.

According to *Aurivillius* ([98] p. 100), it occurs in the Skagerrak all the year round, but less frequently in March and April; according to *Cleve* ([00], p. 19), in the same place, in 1898, it was «common in January, then rare to June, common from July to the end of the year». *Cleve* found it at Plymouth all the year round, with a maximum from July to December.

Thus its maxima and minima appear to occur almost simultaneously along the whole coast of Northern Europe. In the north-eastern part of the summer, it is rarely found in by the coast; but farther from land (Station E<sub>0</sub>), it is sometimes common as early as July. After November, it decreases greatly in quantity, but solitary specimens remain through the winter, at any rate up to March. Inside the fiords, it is on the whole very uncommon.

In the Skagerrak too, according to *Cleve* [97], it occurs «sparingly in the summer, most common in September and October» In the North Sea, it was found in 1898 (*Cleve* [00], p. 20) in some places in March, but sparingly; in July and August it was absent, but in November it appeared in some places in considerable quantities.

This form, according to *Ostenfeld's* investigations, is very rare in the western part of the Atlantic, and on the whole at a considerable distance from the coast of Northern Europe.

In the Skagerrak, it is supposed by *Aurivillius* (l. c. p. 22) to come in from the south-east with the Jutland current. *Cleve* classes it with the Tripos-plankton and southern neritic plankton. In Nordland too, it gives the impression of being an allogenetic organism, which has come from the south with the coast currents. But as yet it cannot well be decided where its centre of distribution is to be sought for.

*Ceratium tripos* var. *longipes*, Bail.

This form is found along the coast of Nordland in great quantities during the first half of the summer, especially June and July; at this time of year it is the most conspicuous of all Peridinia. Later in the summer, it decreases in quantity, but inside the fiords it is still found rather plentifully all through the summer and autumn. As late as the 25th September, 1898, it was found in large quantities at Liland in Ofoten. In the surface-layers, it is true, the more southern forms, *C. tripos* and the variety *macroceros*, were at this time more common; but at a depth of from 40 to 60 metres, it was found in greater quantities than any other Peridinium (Tab. III). For the rest, it seems to be found along the coast all the year round, with a minimum in April.

If any of the varieties of *Ceratium tripos* are to be supposed to be stationary in Nordland, it must be this one; but there are also circumstances which indicate that at any rate it comes in to some extent with the coast currents. It is found, for instance, outside the belt of islands earlier (at Røst on the 24th May, 1899) than within the belt of islands (Herø on the 15th June, 1899, still only sparingly); and even in the first few days of July, it appeared in greater quantities out on the Vesteraalen edge than near the shore. It subsequently becomes the characteristic form of the fiord plankton.

*Ceratium longipes* — as, for the sake of brevity, I shall call it — has a very wide distribution. It is classed by all authors as a northern form. *Cleve* considers it the characteristic form in the northern neritic plankton, *Ostenfeld* in the northern peridinal plankton, which has its centre of distribution in the North Atlantic, north of Iceland.

*Ceratium tripos* v. *macroceros*. Ehr., occurs in Nordland in about the same manner as the principal form, though somewhat less abundantly: Its maximum occurs in August and September.

*Ceratium tripos* v. *scotica*, Schütt, is a rare visitor in Nordland, being only found in the autumn, off Herø in October, 1899 (cf. Tab. XII).

*Ceratium furca*, Duj., on the coast of Nordland occurs very much as *C. tripos*. It may often constitute a very important part of the plankton, e. g. in the lower part of the West Fiord, in July, 1898.

*Ceratium fusus*, Duj., appears in about the same manner as *C. tripos*.

*Dinophysis acuta*, Ehr., may often be common in Nordland, especially in the belt of islands and just outside it. Its maximum occurs in August and September.

*Dinophysis Michaelis*, Ehr. (*D. rotundata* autt.), is also not uncommon, but it is generally found in the fiords, and in the spring, together with *Ceratium longipes* and *Peridinium ovatum*. It is probably an endogenetic neritic form.

*Diplopsalis lenticula*, Bgh., seems, on the other hand, to be allogetic, of southern origin. In the tables for 1898, it has unfortunately been in some measure confounded with *Peridinium ovatum*. *Diplopsalis* is much more frequently met with out on the Edge than near the shore; and in the fiords it is very rare. Its maximum appears to fall in August and September.

*Gonyaulax spinifera* (Clap. & Lachm.) is not infrequently found on the coast of Nordland; but I have not been sufficiently observant of it to be able to say anything of its biological conditions. It is probably a neritic form.

*Peridinium divergens*, Ehr., has been divided, during the last few years, into several varieties with different geographical distribution. In the tables for 1898, I have not yet introduced this division, but have entered all the forms under *P. divergens*, Ehr. s. l. In Nordland var. *depressa*, Bail, is much more common than any of the other forms. It is therefore, in most cases, this variety that is entered as *P. divergens* s. l.

In the tables for 1899, besides separating var. *depressa* from the principal species, I have also separated a form which I have provisionally called var. *conica*. It is figured by Bergh [81], Pl. XV, figs. 43, 44. It is easily distinguished from the principal species by the bluntly conical form of the apical part, while in the principal form and var. *depressa* it is first narrowed and afterwards pointed. The antapical horns too, are blunter than in the principal species; and the little spines on the inner side are either very inconspicuous, or altogether absent.

After the tables had been printed, I noticed that Lemmermann, in one of his recent works [99], has also specified among the numerous

varieties and forms which he has named from the drawings of others, without apparently having seen specimens of most of them, a «var. *sinuosum*, Lemm. nov. var.», Bergh, l. c. fig. 44, and a «var. *acutangulum* Lemm. nov. var.» Bergh, l. c. fig. 43. Future minute investigations may perhaps also show that these forms may really be separated from one another. I have included both under var. *conica*. This designation naturally lays no claim to priority.

The principal form, *Peridinium divergens*, Ehr., s. str., has its maximum in August and September. During these months, it is not uncommon, especially in and outside the belt of islands.

*Peridinium divergens* var. *conica*, Gran, has almost the same occurrence as the principal form. Both these seem to be southern coast forms that are carried northwards with the coast currents in the summer. Cleve classes *P. divergens* with the Styli-plankton and the Tripos-plankton.

*Peridinium divergens* var. *depressa*, Bail. is a more northern form, which seems to keep to the coast of Norway all the year round. It occurs at about the same seasons as *Ceratium longipes*; but even in August, it may still be very common. It is classed by Cleve with the northern neritic plankton, like *Ceratium longipes*. Ostenfeld refers it to his northern peridinal plankton.

*Peridinium pellucidum*, Bgh., and *P. Michaelis*, Ehr., both occur rather commonly on the coast of Nordland. They are not always entered in the tables. They are probably neritic forms.

*Peridinium ovatum*, Pouchet, in its distribution in Nordland keeps pretty closely to *Ceratium longipes* and *Peridinium depressum*. It sometimes occurs in rather large quantities.

### Tintinnodea.

Among the Tintinnodea, I have only taken into account the species that occur somewhat regularly, and are thus of some significance to the character of the plankton.

There are two species that without comparison are more common than any of the others, namely, *Cyrtarocylis denticulata* (Ehr.) Fol. s. l. and *Ptychocylis urnula* (Clap. & Lachm.), Brandt. But these two sometimes occur in great quantities; in a few samples they constitute an important part of the whole plankton. I have not separated the different varieties or sub-species that Brandt [96], Ostenfeld [99], and Jørgensen [99] specify.

Both the above-mentioned species — or form-groups — are found in Nordland at any rate all the summer and autumn, and probably singly all the year round. At Bergen, according to *Jørgensen* [99], they are found all the year through — *Cyttarocyliis denticulata*, however, not in January.

*Aurivillius* considers both species, from their occurrence in the Skagerrak, to be allogetic, belonging to the mixed water between the Gulf Stream and the coast water on both sides of the North Atlantic. *Cleve* classes them with the Tricho-plankton ([99, 1], p. 7).

In Nordland, they are found outside the belt of islands, among the islands themselves, and in the fiords, with nearly equal frequency. They seem to have a distribution-centre in the Nordland coast-waters, although they are true oceanic species.

All the other species seem to be emphatically neritic. They have their maximum in Nordland in the warmest season of the year, and in the winter they disappear from the plankton. In a few species, *Amphorella subulata* and *Cyttarocyliis serrata*, I have observed cysts, which probably sink to the bottom, and pass the winter in a quiescent state.

I will here mention the annual maximum for the most important species. For purposes of comparison, the months in which they are found in the plankton near Bergen are appended from *Jørgensen's* paper [99].

	Maximum in Nordland	Occurrence at Bergen
<i>Amphorella Steenstrupii</i>	August to October	August to December
— <i>subulata</i>	July to September	May to November
<i>Cyttarocyliis serrata</i>	July to August	June to November
<i>Tintinnopsis beroidea</i>	July to October	November to December
— <i>Campanula</i>	July to September	July to December
<i>Tintinnus acuminatus</i>	August to October	June to December

The *Tintinnopsis* species keep close in to shore, and especially inside the fiords (e. g. in Ofoten, July 28, 1899, Tab. IX). The other species may also be found out on the banks. Here they may make their appearance earlier in the summer (in the first half of July), while near land they are not found in any quantity until August.

### Radiolaria.

Only one species occurs with sufficient regularity and in sufficient quantities to characterise the plankton, namely, *Acanthometra echinoides*,

Clap. & Lachm. (*Acanthonia quadrifolia*, Häckel). It has its maximum in August, but is sometimes still very plentiful in September. In July it is only found out on the banks, and not near the shore. In 1898, it appeared at Bodø in enormous quantities (Tab. IV).

It also occurs outside the belt of islands, but only rarely in the fiords. According to *Aurivillius*, l. c. p. 20, it is an oceanic plankton form from the temperate North Atlantic and the Pacific.

*Plagiacantha arachnoides*, Clap., occurs regularly, but rather sparingly.

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Of other Protozoa may be noticed *Globigerina bulloides*, d'Orb. which is found not infrequently out on the banks, but not in the fiords. It is a true oceanic organism, which is only brought in to the coast by ocean currents.

#### Copepoda.

I have not been able to make a thorough report of the Copepoda, but have been obliged to content myself with specifying those species which appear in such great quantities that they determine the character of the plankton. Of these there are really only 3 or 4 species in Nordland, namely, *Calanus finmarchicus*, *Microsetella atlantica*, *Oithona similis*, and sometimes *Pseudocalanus elongatus*.

#### *Calanus finmarchicus*, Gunn.

This species is found in enormous quantities, and, also because of its considerable size, plays an important part in the economy of the coast waters. I have therefore paid special attention to it\*.

I have attempted to determine its appearance quantitatively by counting all the adult specimens in each sample; but even if it be supposed to be evenly distributed over wide tracts, the determination is nevertheless scarcely exact, as some individuals, by their rapid movements, are likely to get away from the comparatively narrow opening of the quan-

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\*) I have not weighed it in a living state. Its weight after preservation in alcohol may be approximately calculated from a couple of samples from Ofoten, July 28th, 1899, where it occurred almost unmixed. Here 1757 full-grown specimens weighed 0.69 grammes, so that each single specimen weighed about 0.4 milligrammes.

titative bag, especially as the bag, in being drawn up, exerts a considerable upward pressure upon the surrounding water.

The figures, however, that the method of counting in this case gives, may at any rate give much information as to where and in what quantities the animal occurs, even if they do not give any actual value for the number of animals living in the column of sea-water, filtered by the bag.

The results show with complete certainty that *Calanus finmarchicus*, during the early part of the summer, is found in great quantities in the fiords, where the water at that time of year is still colder than in the belt of islands and on the banks. In July it occurs outside the belt of islands only sparingly (Tab. VII, VIII; Stations E<sub>1</sub> to E<sub>2</sub> inside Eids Fiord, E<sub>4</sub> to E<sub>8</sub> outside the belt of islands).

During the first few days of July, it was still found in enormous quantities in Eids Fiord and the neighbouring sounds and fiords, Sortland's Sound, Siger Fiord, Hadsel Fiord, sometimes up to the very surface, but generally from a depth of from 10 to 15 metres down to the bottom. By the 24th or 25th July, however, it had already diminished greatly in quantity, while at the same time the water in the upper layers had become warmer, and salter water had streamed in along the bottom. In the deeper layers, they were still found in no small quantity, but in the surface-layers they occurred very sparingly.

In the Ofoten Fiord, however, which is much longer and deeper than Eids Fiord, they were still found on the 28th July in great quantities (Tab. IX). The distribution will be best seen from the following table:

	Statin O <sub>3</sub>	Station O <sub>2</sub>	Station O <sub>1</sub>
Depth.	Mouth of Fiord	Middle of Fiord	Head of Fiord
	Lødingen	Liland	Narvik
0—20 m.	2	60	1757
20—40 »	4	1679	681
40—100 »	47 (40—70 m.)	84	110 (50—109 m.)

It is thus found in the greatest quantities in the upper part of the fiord. Here too, however, it diminishes in quantity in the course of the summer; this was at any rate the case in 1898. In the same year it remained longer in Ofoten than in any other of the fiords examined. I append from Table III the following figures:

Liland in Ofoten (Station O<sub>2</sub>).

1898

August 9      September 25

0—20 m.	655	87
20—40 m.	390	25
40—60 m.	121	7

Narvik in Ofoten (Station O<sub>1</sub>).

1898

August 7      September 25

0—20 m.	376	0
20—40 m.	84	3
40—60 m.	21	6

In July, 1898, it was still more numerous than in August; but as at that time the quantitative bag was not ready for use, I am unable to give any figures.

In the fiords then, *Calanus finmarchicus* diminishes in number towards the end of the summer and in the autumn. Out on the coast-banks, the reverse appears to be case. In the beginning of July, 1899 (Table VII), it was found only in small quantities outside the belt of islands, while Eids Fiord was full of it. At the end of July (Table III), it was found nowhere in great quantities, but most numerous outside the belt of islands (Station E<sub>4</sub>); and at the end of August (Table X), it appeared in large quantities out above Vesteraalen edge, while it had nearly disappeared from Eids Fiord. In September, 1898, it was found both in the fiord and on the banks, but most abundantly over Vesteraalen edge.

In the summer of 1898 also, it increased in quantity outside the belt of islands. At the mouth of the West Fiord, even in July, it was rather scarce (Table III, Stations I—III); but on the 8th September (Stations V<sub>1</sub> & V<sub>2</sub>), it was to be found in large quantities.

There is moreover this difference between its appearance in the fiords and out on the banks, namely, that the specimens found in the early summer are all large and full-grown. Out on the banks in the autumn, there are many different sizes and stages of development to be found. I have, however, only counted those specimens that were sufficiently large to be easily distinguished from all other species with the naked eye.

With regard to the occurrence of the species on the coast of Nordland at other seasons, little is known at present. *Nordgaard's* investigations [99] show that in February and March it is found scattered both inside and outside the belt of islands. It appears to occur most abundantly in the deeper layers, especially inside the fiords.

The investigations that I have had carried out all through the year at Herø and Røst, were made with too small nets to allow of their giving any complete information as to an animal that is so large and so quick in its movements; but if the species occurs in great quantities, it would still appear in the samples, a fact of which I have been able to convince myself. It is therefore very remarkable that the three series of samples give corresponding results. *Calanus finmarchicus* is found in large quantities in all the series, in the samples of May (Tables XI—XIII), at Røst at the beginning of June also; but in all the others, I have seen only single specimens. It must thus probably be a general rule that out in the Nordland belt of islands, it has its maximum in May.

Is *Calanus finmarchicus* stationary on the coast, or does it come in with the currents from outside? The solution of this question is of no little importance for a comprehension of the economy of the whole coast-water, as this species alone probably constitutes quantitatively the greater part of the animal plankton of the coast-water.

*Calanus finmarchicus* is a pronounced oceanic organism with a very wide distribution. According to *Aurivillius* [98], it is arctic and antarctic in a wider sense, with a eurythermal tendency; it is even found in the Tropics, but in smaller quantities, and the specimens are not so powerfully developed as the arctic ones.

Cleve [99, 1] reckons it among the Tricho-plankton, and the northern neritic plankton, which is also in accordance with its wide distribution. In the Skagerrak it is found all the year round deep down, but is absent from the surface-layers in the summer.

On the coast of Nordland also, it remains, probably in deep water, all the year round; but on the other hand, it is not impossible that a portion of the large quantities that fill the fiords in June and July, are derived from an in-flowing in May.

*Microsetella atlantica*, Brady & Rob.

This characteristic species is found in Nordland all the year through; its maximum seems to occur in September. In Gratangen Fiord, it was

found on August 31st, 1898, in all stages of development, in enormous quantities. It is moreover met with in greater or smaller quantities both outside and inside the belt of islands.

Its distribution in other respects seems, according to *Aurivillius* [98], to be about the same as that of the foregoing species. *Cleve* [99, 1] places it among the Styli-plankton, thus looking upon it as a southern form.

*Oithona similis*, Claus.

This species is perhaps still more common than the preceding one; it is seldom absent in any plankton-sample from Nordland. It appears to have its maximum from August to October.

According to *Aurivillius*, it is probably endogenetic in the Skagerrak; he moreover specifies it as a temperate form from the North Atlantic, with a eurythermal tendency. *Cleve* [99, 1] places it in the Styli-plankton.

On the coast of Nordland it remains, probably all the year round, as a stationary organism. The supply may of course be renewed by an influx from the North Atlantic Ocean.

*Pseudocalanus elongatus*, Boeck,

also sometimes appears in large quantities, but not so frequently as the two preceding species.

**Cladocera.**

*Evadne Nordmanni* Lovén and *Podon polyphemoides*, Leuck, are both found rather frequently, especially in the upper layers of water. They have their maximum in August and September. They are probably stationary on the coast.

Of other organisms, there are a few larger forms that are seldom, or only singly, met with in the samples that are taken in bags of the finest silk gauze; but with a larger bag of coarser gauze, I have taken up larger quantities. A complete account of them will follow in a subsequent paper; here I will mention only two forms, to which I have given special attention.

*Spadella hamata*, Möbius,

is often found in large quantities in the fiords together with *Calanus finmarchicus*. It is a pronounced arctic organism, which, farther south,

is only found at great depths. I have found it in Ofoten and in Eids Fiord up to 50 metres below the surface.

*Spirialis retroversus*, Flemming,

is found outside the belt of islands in August and September, sometimes in great quantities. It is probably brought here by currents from the south. It is eaten by the herring, which can only digest it slowly, on account of its firm shell. It is therefore dreaded by the fishermen, as it decays in the herring's intestinal tube, when the herring is salted without removing the stomach.

## Plankton Communities.

*Cleve* [97] and *Ostenfeld* [99] have established plankton types or plankton communities, which characterise the various ocean regions at certain seasons.

*Cleve* has named his types after a few leading forms, and has thus obtained a limited number of types with clear, simple designations. But as the leading forms have a very wide distribution, it is unavoidable that one plankton-type may have an essentially different character in different regions, even if the same leading form be found in both places. On the other hand, the leading species may sometimes appear in such small quantities — as *Ostenfeld* also points out — that it can only very improperly be said to characterise the plankton.

*Ostenfeld's* names for the plankton communities are taken from their distribution, and from the time of year at which they have their maximum. The names are biologically correct, and they may also be practical in investigating a limited area. That I nevertheless prefer *Cleve's* designations is because I consider it desirable that the names of the communities should tell to some extent which species are characteristic. *Ostenfeld's* «oceanic spring-plankton», for instance, is far too general and indefinite a designation for the community that is found in spring in the region that he has investigated. Plankton communities may be found in other places with quite another composition, but for which the name would suit just as well. *Ostenfeld* has indeed also an «eastern oceanic spring-plankton» as a sub-division; but the divisions that can be made in this way, will nevertheless scarcely suffice to give adequate designations.

*Cleve's* designations are too sharp and schematic, but it is better to define too sharply than too vaguely.

In the following account, I have therefore adopted *Cleve's* names with some few additions and changes, which, in my opinion, were necessary. In so doing, however, it has not been my wish to express an opinion as to the hypotheses concerning the course of the ocean currents, which *Cleve* has associated with his names for the plankton-types. In the last section I will discuss more fully the question as to how much can be concluded, from the facts hitherto known, with regard to the connection between the ocean currents and the character of the plankton in the North Atlantic and on the coast of Nordland.

#### A. Neritic Communities.

Neritic species are those that either live exclusively near the coasts, or at any rate have their centre of distribution near the coasts, whence they may also be carried out by currents into the open sea. Most of the neritic forms are *meroplanktonic*; they pass in their developmental cycle through a bottom stage, which is generally a quiescent stage. They are thus directly dependent on the bottom. They are found in greatest quantities in shallow water; our deep fiords are very deficient in true neritic organisms, but the belt of islands is their true home.

The coast currents will probably also carry the neritic organisms from one place to another. The neritic species that are found in a place, can therefore very well be of foreign origin; but it seems to be a rule that they do not drift long distances, and in any case, the local, endogenetic forms in each place will be in the majority as compared with the allo-genetic coast forms.

1. Tænio-plankton, or Arctic Neritic Plankton,  
as it occurs in Nordland, is a pure diatom-plankton. It consists of the following neritic diatoms, which are also found on the coasts of Greenland and Spitsbergen:

- Achnanthes teniata*
- Biddulphia aurita*
- Chaetoceras contortum*
- *debile*
- *diadema*
- *furcellatum*\*
- *sociale*

*Chaetoceras teres*  
*Coscinodiscus polychordus*  
*Fragilaria oceanica* \*  
*Lauderia fragilis* \*  
*Navicula Vanhöffenii* \*  
*Podosira glacialis*  
*Skeletonema costatum*  
*Thalassiosira gravida*  
— *hyalina* \*  
— *Nordenskiöldii*

This community is found on the coast of Nordland especially in April, but only close to the coast. It has a somewhat different character in different places. At Røst and other places in Lofoten, *Fragilaria oceanica* predominates; at Herø in Helgeland, *Chaetoceras sociale*; and outside Romsdal, where it is also found at about the same time of year, and of the same composition, *Chaetoceras debile* is the predominating species.

On the coast of Greenland, besides these, there are also some other species, but only forming subordinate component parts (cf. Cleve [99, 1], p. 8):

*Amphiprora hyperborea*, *Chaetoceras septentrionale*, *Coscinodiscus bioculatus*, *Eucampia grænlandica*, *Fragilaria cylindrus*, *Navicula septentrionalis*, *Nitzschia frigida*, *Pleurosigma Stuxbergii*.

From February to April, a neritic diatom-plankton is found in the Skagerrak, which has many species in common with the arctic neritic community, and which Cleve has in some measure confused with the latter. It may very well retain Cleve's designation, Sira-plankton, as *Thalassiosira* species are as a rule in the majority.

In the above list, I have indicated by an asterisk the species that are absent from the Skagerrak Sira-plankton, but the latter on the other hand, has some others, of which I may mention *Chaetoceras constrictum*, *scolopendra*, and *simile*, *Leptocylindrus danicus*, *Rhizosolenia setigera*, *Thalassiosira gelatinosa*.

## 2. Phæocystis-plankton.

The Tænio-plankton is replaced on the coast of Nordland directly by a very homogeneous Phæocystis-plankton, composed almost exclusively of *Phæocystis Pouchetii* (Har.) Lagh. It was first demonstrated on our coast by Lagerheim [96], who found it in large quantities at Tromsø in 1895. It appears first together with the arctic neritic diatoms; but in

the latter half of April, these diatoms form spores, and disappear from the plankton, and for a short time *Phæocystis* is quite predominant. *Ostenfeld* ([99] p. 87) mentions a similar *Phæocystis*-plankton, which appears at the south point of Greenland in April, and in Iceland in June and July.

### 3. Contorto-plankton.

#### Or Sub-arctic Neritic Plankton.

In the autumn — September and October — there may be found in several places on the coast of Northern Norway, a neritic plankton that consists chiefly of diatoms. It comes under *Cleve's* type «northern neritic plankton»; but under this heading are also included the coast plankton of Iceland, and to some extent the subsequently treated Longipes-plankton. I therefore give it here under a special name.

*Chætoceras contortum*, *lacinosum* and *Willei*, and *Skeletonema costatum* may be regarded as characteristic forms. The minor component parts are to some extent the same as are found in the winter in the arctic plankton. The following species occur:

*Cerataulina Bergonii*

*Chætoceras constrictum*

— *contortum*

— *coronatum*

— *curvisetum*

— *debile*

— *diadema*

— *didymum*

— *lacinosum*

— *teres*

— *tortissimum*

— *Wighami*

— *Willei*

*Leptocylindrus danicus*

*Skeletonema costatum*

*Thalassiosira gravida*

— *Nordenskiöldii*

It is probable that the neritic Tintinnodea occurring on the coast of Nordland must be entered here, viz. *Amphorella Steenstrupii*, *A. subulata*,

*Cyrtarocyis serrata*, *Tintinnus acuminatus* and further a whole series of larva-forms, and perhaps *Evadne Nordmannii* and *Podon polyphemoides*.

This plankton stands in the same relation to the arctic neritic plankton of Nordland, that the *Didymus*-plankton of the Skagerrak does to the Sira-plankton. A few of the *Didymus*-plankton species are also found in Nordland (e. g. *Ch. didymum*, *curvisetum*, *Cerataulina Bergonii*); but most of the forms are absent.

A plankton corresponding to this community was found by Cleve [97] in Tromsø Harbour, on June 12th, 1896. It may be found in small quantities all through the summer, but appears, from my investigations, to have its maximum in September and October. It seems to occur in even greater quantities in Tromsø and Finmark than in Nordland, where there is as a rule very deep water between the islands.

### 3 b. *Skeletonema*-plankton.

An extreme form of the foregoing community is sometimes found in the summer on the surface within the belt of islands, and even at the head of the fiords. It consists almost exclusively of *Skeletonema costatum*. It was found at the very end of Eids Fiord on July 25th, 1899 (Tab. XII). In August, 1899, at Herø, this hyper-neritic plankton had been displaced by forms with a more oceanic character.

In the fiords, large quantities of *Tintinnopsis* species may be found (*Tintinnopsis campanula*, *beroidea*, etc.), which seem to be pronounced neritic species. *Tintinnopsis campanula* also appears regularly on the west coast of Norway, though rather sparingly, in the belt of islands; but in the Hardanger Fiord, Jørgensen found it in great quantities ([99], p. 22). It is one of the few neritic species that are especially to be found in the deep fiords.

### 4. *Halosphæra*-plankton.

*Halosphæra viridis* is found on the coast of Nordland from September to March, often in considerable quantities. As there are no other species that occur at the same time, it must form a community by itself. It is not yet decided, however, whether it is actually neritic. It appears in the Skagerrak and the North Sea at the same time of year as in Nordland.

## B. Oceanic Communities.

### a. Diatom Communities.

#### 5. Disco-plankton

(Oceanic Winter Plankton, *Ostenfeld*).

This community has been treated of by *Ostenfeld* ([99], p. 82), and by myself (*Hjort & Gran* [99], p. 19). On the coast of Nordland it is found outside the belt of islands, especially during the first few months of the year. The characteristic forms are *Coscinodiscus oculus iridis*, *C. radiatus* and *C. stellaris*.

#### 6. Nitzschia-plankton.

The *Nitzschia*-plankton is a very characteristic diatom-plankton, found just outside the belt of islands especially in July. In the latter half of the month, it goes within the belt of islands, but not into the fiords. The predominant characteristic form is

*Nitzschia delicatissima*,

In a subordinate degree appear

*Nitzschia seriata*, and

*Chaetoceras criophilum*, and less frequently

— *decipiens*.

There are, moreover, the characteristic forms in the succeeding community, *Rhizosolenia alata* and *Rh. styliformis*, and a few neritic forms, e. g. *Chaetoceras debile*, *laciniosum*, etc.

In October, 1898, this plankton was found in large quantities in the fiords in the province of Tromsø, together with neritic diatoms (Tab. VI).

The *Nitzschia*-plankton has a great resemblance to *Ostenfeld's* «oceanic spring plankton», which occurs in «the North Atlantic from April to June, and in the Irminger Sea in August» (l. c. p. 83). It must probably be regarded as a special form of this community. Its distribution in the north-eastern part of the North Atlantic is as yet little known. There is no necessity for supposing that it has come with currents to the coast of Norway from the west side of the Atlantic, even though this is not impossible. In May, 1896, it was found in the middle of the Gulf Stream to the north of the Shetland Isles (*Hjort & Gran* [99], Tab. 2, Station 50).

This plankton does not agree with any of *Cleve's* types. Biologically it perhaps most nearly corresponds with the Tricho-plankton; but the characteristic forms of the Tricho-plankton (*Thalassiothrix longissima*, *Chaetoceras atlanticum*, *Rhizosolenia semispina*) are exceedingly rare on the coast of Nordland.

#### 7. Chæto-plankton (Cleve).

This type, established by Cleve, is characterised by *Chaetoceras decipiens*, which is one of the most common plankton-algæ on the coast of Nordland. Wherever the plankton is rich in diatoms, oceanic or neritic, it is found among the others, and in very considerable quantities; but nevertheless it is seldom the characteristic form of the plankton.

A peculiar form of fairly pure Chæto-plankton was found in the inner part of Ofoten on July 28th, 1899. It consisted of *Chaetoceras decipiens* and *Ch. criophilum*. The diatom cells gave the impression of degeneration. I consider it probable that these species have come into the fiord earlier in the summer.

In the beginning of July, a similar oceanic diatom plankton was found at the head of Eids Fiord. Here, however, *Chaetoceras criophilum* was the predominating species.

#### 8. Northern Styli-plankton.

This is found in large quantities off the coast of Nordland, especially in August and September. It corresponds with *Cleve's* Styli-plankton, but has nevertheless a different character from the Styli-plankton found, for instance, in the North Sea and west of Scotland in the summer. The species in this plankton are much more abundant, but the number of individuals can hardly be greater than off the coast of Nordland. *Cleve* also mentions ([99, 1], p. 4) that about half the forms of the Styli-plankton do not go farther north than to the Faroe-Shetlands channel, and that therefore the Styli-plankton has a very different character in the various regions where it appears.

The form of Styli-plankton found in the North Atlantic about the coast of Norway and Spitsbergen may very well be called northern Styli-plankton

The characteristic forms are:

*Rhizosolenia alata*, both the principal form and f. *gracillima*  
predominating

*Rhizosolenia styliformis*

— *Stolterfothii*

— *Shrubsolei*

*Dactyliosolen mediterraneus* v. *tenuis*

*Corethron hystrix*

*Diplopsalis lenticula*

*Globigerina bulloides*

*Spirialis retroversus*

*Sagitta bipunctata*, with several other animal forms.

Cleve also includes *Microsetella atlantica* and *Oithona similis* among them, as they are also regularly found with the above-named species; but in my experience, the majority of these species keep nearer land, especially in the company of *Peridinia*, and their biological conditions seem to class them with the Tripos-plankton.

*Rhizosolenia alata*, the predominating form in the northern Styli-plankton, is also the characteristic form in the Baltic current, which in the early summer flows out of the Skagerrak onwards along the west coast of Norway. In Nordland its occurrence seems to be distinctly oceanic. It is indeed not impossible that a great many may be derived from individuals that have moved northwards along the west coast of Norway with the Baltic current; but it is found in Nordland together with purely oceanic forms in layers of rather salt water. If water and organisms originating from the Baltic current are found off Nordland, both the water and the organisms it contains are so mixed, that they have acquired an altogether oceanic character.

This northern Styli-plankton is found out on the banks as early as the beginning of July, while the *Nitzschia*-plankton forms a band just outside the belt of islands, and the *Longipes*-plankton fills the fiords. In the course of the summer, it penetrates farther in; and in the latter half of August and the beginning of September, it comes right in to the belt of islands, at first in the deeper layers. It remains at any rate all September, probably also during October. In the middle of October, 1898, it was found in large quantities far up the Øx Fiord in Finmark, where at the same time there was an abundant inpouring of herring.

The Styli-plankton does not appear to occur every year in the same manner. In 1895, it seems to have come right in to the shore as early

as the first few days of July (*Hjort & Gran* [99], Tab. 1, Stations 14—19); but in September it had already almost disappeared.

b. Peridinal Communities.

9. Longipes-Plankton.

(Northern Peridinal Plankton, *Ostenfeld*).

*Ostenfeld* describes ([99], p. 86) a northern peridinal plankton from the North Atlantic, where, in his opinion, its centre of distribution is north of Iceland in the summer. The characteristic forms are:

*Ceratium tripos* v. *longipes*

*Peridinium divergens* v. *depressa*

— *ovatum*

— *pallidum*

On the coast of Nordland an altogether similar plankton occurs in May, June and July, though *Peridinium pallidum* is not actually proved to be present. In July, outside the belt of islands it is replaced by plankton communities with a more southern character; but in the fiords it remains longer, sometimes until September. Together with these Peridinia, there is found a majority of *Calanus finmarchicus*, which therefore, on the coast of Nordland, may naturally be referred to this community.

The Longipes-plankton has also been observed by *Cleve*. He looks upon it as a form of the northern neritic plankton, which again he considers to be a derived Tricho-plankton, and thus a community of West Atlantic origin.

It is possible that the north Icelandic peridinal plankton, for instance in the spring, may be directly connected with the Nordland Longipes-plankton; but this is not a necessary supposition, and has not yet been proved.

The Longipes-plankton embraces oceanic forms of northern origin, which have their maximum in the early part of the summer, and of which some individuals, at any rate, remain near the coast all the year round. Some may perhaps also come in with the volumes of oceanic water, but it is characteristic that these forms are found in greater quantities along the coast than in the open sea.

10. Tripos-plankton (*Cleve*).

This plankton consists of Peridinia and Crustacea that are oceanic, but may remain near the coast all the year round, with a maximum in the warmest months, August to October. While the preceding community is of northern origin, the Tripos-plankton has its greatest distribution south of Nordland.

This community is nearly allied to the Styli-plankton. *Cleve* considers it to be derived from Styli-plankton that has approached the coasts. It frequently occurs mixed, partly with Styli-plankton, partly with the neritic autumn plankton of Nordland, Contorto-plankton.

On the coast of Nordland, its appearance may vary considerably. It ought perhaps therefore to be divided up into special types with different biological characters; but a division of this kind can hardly be made on the basis of the material at present possessed.

Characteristic forms:

*Ceratium tripos*

- v. *bucephala*
- » *macroceros*
- *fuscus*
- *furca*

*Peridinium divergens*

- *pellucidum*

*Dinophysis acuta*

*Cyrtarocyliis denticulata*

*Ptychocyliis urnula*

*Acanthometra echinoides*

*Microsetella atlantica*

*Oithona similis*.

The number of individuals in the Tripos-plankton is very great, but the various species may vary in the frequency of their occurrence. Sometimes *Ceratium tripos* predominates, sometimes *C. furca*, and again in other places, *Ceratium tripos* v. *macroceros* and *C. fuscus*. *Cyrtarocyliis denticulata*, *Acanthometra*, *Microsetella* and *Oithona* may also in different places each appear in such quantities as to determine the character of the plankton.

But it is difficult to draw sharp boundary-lines between all the forms that this summer plankton can assume. The following facts are common to all the species:

- (1) That they are oceanic,
- (2) That they are found in especially large numbers upon the coast,
- (3) That they can remain on the coast all the year round, and
- (4) That on the coast they have their maximum from August to October, the warmest months in the sea.

The first three characters they possess in common with the type species of the Longipes-plankton; but the latter have not their maximum in the summer, but from May to July.

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## Quantitative Plankton Investigations.

In order to obtain an idea of the abundance of the plankton, a quantitative bag, after *Hensen's* model, was employed after August, 1898. It was furnished with a closing mechanism, constructed by *C. G. Joh. Petersen* [98]. The opening was of the same size as in the bag used by *Petersen* himself, namely, about 0.09 sq. metres.

The quantity of plankton is determined by weighing the preserved samples in the manner employed by *Petersen*. The figures obtained by this method do not give any exact result. On the one hand, the alcohol extracts some of the dry substance of the organisms, and not an equal amount in all the forms (cf. *Brandt* [98]); on the other hand — and this is a more serious source of inaccuracy — it is not possible to remove the liquid (alcohol) that is retained by the force of capillarity between the organisms; and the various organisms retain very various quantities. Diatoms and Radiolaria, which leave comparatively large spaces between the cells when they sink together, on being weighed increase the total weight with disproportionately large values, while Peridinia and Crustacea collapse much better.

The same disadvantage attaches to the method employed by *Hensen*, *Schütt*, etc. for measuring the volume of the plankton samples; here too, the diatoms give too high values. I have also tried this mode of procedure; it may give results that are almost as good as those obtained by weighing, but it takes longer.

*Hensen's* method of counting, which is the most exact hitherto attempted, is too laborious to admit of its being employed at the initiatory stage at which these investigations still stand. It is first of all necessary to obtain a large number of observations in order to get a

general view of the various factors that influence the distribution of the plankton. When the preliminary survey is obtained, the time has come to work out the results in detail by an exact, but laborious method. And before it is taken into general employment, it must be ascertained that the collection is actually quantitative. Several writers have shown that a number of small organisms slip through even the finest silk gauze, and it is perhaps of still greater consequence that many of the larger organisms are frightened away by the pressure that arises round the net. According to my experience, which is certainly that of many others before me, it is of the greatest importance to use coarse-meshed gauze in addition to the fine-meshed, as the latter is less fitted for the capture of larger organisms. I have attempted to determine approximately the distribution of *Calanus finmarchicus* by counting, as mentioned above (p. 51).

The figures obtained by the weighing-method are at any rate a standard of the abundance of the plankton, by which the several samples can be mutually compared; and as *Petersen* has employed a similar bag, the plankton in Nordland can also, to a certain extent be compared with the samples from the Skagerrak which he has examined, and also with some samples from the Christiania Fiord which are mentioned in *Hjort's* and my work in this volume [00].

The quantity of plankton in Nordland is not to be compared with the quantities that may be found in the Kattegat and Lim Fiord. The richest plankton sample that I have from northern Norway, I took outside Eids Fiord in Vesteraalen, on September 22nd, 1898, from a depth of 40 metres up to the surface. It weighed 2.84 gr., and contained great quantities of diatoms (*Rhizosolenia alata*), but also many Peridinia and Crustacea (cf. Table V. Station E4). A sample from Gratangen Fiord in the province of Tromsø, taken on August 31st, 1898, from a depth of 30 metres up to the surface, was perhaps still richer. Its weight was 2.54 gr., and as it consisted almost exclusively of Crustacea (*Microsetella atlantica*), it was probably richer in substance than the sample from Eids Fiord (cf. Table VI).

In Lim Fiord, *Petersen* has taken samples that have contained as much as 27 gr.; and even out in the Kattegat he found (May 25th, 1897) near Læsø channel, at a depth of from 7 to 10 fathoms, no less than 13.5 gr of plankton. Both these samples contained great quantities of diatoms.

In the coast-waters of Nordland, the plankton is thus much poorer than in the Kattegat and in Lim Fiord. Samples weighing more than 2 grammes are a rarity, even in the summer and autumn.

The richest of all the samples taken from a depth of 20 metres up to the surface, weighs 2.46 gr. (Bodø, September 5th, 1898, Tab. IV), and the poorest, 0.04 gr. (Narvik in Ofoten, Station O1, September 25th, 1898). The average weight of 39 samples is 0.68 gr. The maximum, minimum, and mean of 36 samples taken from depths of 20 to 40 metres, are as follows:

Maximum	Minimum	Mean
1.73 gr.	0.01 gr.	0.50 gr.
and of 25 samples, taken from depths of 40 to 60 metres,		
1.85 gr.	0.05 gr.	0.37 gr.

The plankton is thus generally richest in the upper water-strata, but the difference is not always equally marked. At the beginning of the summer, when the water deep down is still cold, while the surface-layers to a depth of from 10 to 20 metres have become warmed, these surface-layers are as a rule quite rich in plankton, while the deeper layers are very deficient. Later in the autumn, when the difference in temperature is gradually equalised, the plankton as a whole becomes more abundant, and is somewhat more evenly distributed downwards, at any rate to a depth of 50 metres.

But there are many exceptions to this rule. In the belt of islands and out on the coast-banks especially, where the currents may be strong, layers of water may be found one above another of different origin, and with different plankton; and in such a case, the lower layers may be richer than the surface-strata. The abundant plankton of *Calanus finmarchicus*, which is found in the fiords in the early summer, also often forms an exception to this general rule. *Calanus* is frequently just as numerous in the depths as in the surface-layers; and in the fiords it sometimes appears in such great quantities as to constitute the bulk of the plankton collected.

As a rule, most plankton is found in the belt of islands, or just outside it, while the quantity decreases both up the fiords and out towards the open sea. A few figures will most clearly demonstrate this.

	July, 1899.	August, 1899.	September, 1898.
E <sub>2</sub>	0—20 m. 0.39 gr.	0—50 m. 1.41 gr.	0—20 m. 0.42 gr.
	20—40 " 0.36 "	50—100 " 0.18 "	20—40 " 0.29 "
			40—60 " 0.13 "
E <sub>4</sub>	0—20 m. 0.69 gr.	0—20 m. 0.15 gr.	0—40 m. 2.84 gr.
	20—40 " 1.49 "	20—50 " 1.65 "	40—60 " 0.53 "
	50—100 " 0.12 "	50—100 " 1.00 "	
E <sub>6</sub>	0—20 m. 0.16 gr.	0—20 m. 0.69 gr.	0—20 m. 1.34 gr.
	20—40 " 0.95 "	20—50 " 0.45 "	20—40 " 0.16 "
	50—100 " 0.62 "		40—60 " 1.08 "

Quantitatively, the coast plankton has, on the whole, its maximum in August and September, as may be seen from Table IV; but there are many factors which interfere, and make the matter very complicated.

Quantitative plankton investigations have not yet been made in Nordland in the winter and spring; but judging from the samples collected at Røst and Herø (Tab. XI—XIII), it may safely be said that at no season of the year is there such an abundant plankton as in August and September. The plankton seems to have its absolute minimum during the first few months of the year — January to March; but in April and May, there is a secondary maximum, which is first due to the revival of the arctic neritic diatom-plankton.

### **The Annual Periods of the Coast Plankton.**

The plankton on the coast of Nordland varies in abundance and composition with the time of year, like the plankton of the Skagerrak or the North Sea. As I shall show in the next section, the plankton at any rate in the summer, is of a different character out on the banks, in the belt of islands, and in the deep fiords; and it is probable that this difference asserts itself all through the year.

But the researches that have hitherto been made in the winter and spring, are almost without exception taken in or just outside the belt of islands. Only a few of *Nordgaard's* samples have been taken either out on the banks, or in the confined fiords; and they are not sufficient to give any complete series for comparison. We must therefore content ourselves with a general view of the plankton of the belt of islands at various seasons of the year.

Up to the present, there are connected series of samples all through the year from Herø in Helgeland (Tab. XI, XII) and from Røst in Lofoten (Tab. XIII). The series from Røst is perhaps the most illustrative. The samples were collected by Mr. J. Nilsen, Røst. Table XIII begins with July, 1898; the plankton is not yet very abundant, and consists of *Peridinia*, especially the characteristic forms of the Tripos-plankton. Later in the summer it increases in abundance. In September, great quantities of *Rhizosolenia alata* are found, consequently Styli-plankton; but in October this has already vanished or withdrawn from the shore. In September and October some neritic diatoms are found, but in no great numbers *Halosphaera viridis* appears for the first time at the beginning of September.

The characteristic forms of the Tripos-plankton (*Ceratium tripos*, *macroceros*, *fuscus*, *furca*, *Microsetella atlantica*, *Oithona similis*) appear to have their maximum in September and October. From the beginning of November, they decrease in quantity, and then no new element appears in the coast-plankton until the latter half of March.

The plankton therefore becomes continually poorer and poorer. It has its minimum during the first three months of the year, when it consists only of *Halosphæra*, a scanty Tripos-plankton, and a few specimens of the *Coscinodiscus* species, which form the oceanic winter plankton, (Disco-plankton). This plankton community, according to Nordgaard's investigations (Hjort & Gran [99], Tab. 5), is found well represented outside Lofoten during the winter months.

In March and April, an abundant Tænio-plankton is found, in which, at Røst, *Fragilaria oceanica* and *Chaetoceras furcellatum* are the species occurring most frequently. At the same time and a little later, an abundant Phæocystis-plankton is found, lastly in May and June come the northern Peridinia (*Ceratium longipes*, etc.) and *Calanus finmarchicus*. In the beginning of July, 1899, an abundant *Nitzschia*-plankton was found at Røst, and also outside Vesteraalen.

The tables for Herø (XI, XII) show that as a whole, the plankton is the same as at Røst. It is richer in larvæ of littoral animals, and in other neritic forms; but on the other hand, the oceanic communities are more scantily represented. The developmental series is the same — for instance, in 1899:

- |               |   |
|---------------|---|
| Jan. to March | — a scanty Tripos-plankton and <i>Halosphæra viridis</i> .  |
| April         | — Tænio-plankton, <i>Chaetoceras sociale</i> predominating.   |
| May           | — <i>Phæocystis</i> -plankton.  |
| May to June   | — <i>Longipes</i> -plankton — <i>Calanus finmarchicus</i> with northern Peridinia ( <i>Peridinium depressum</i> , <i>P. ovatum</i> ).   |
| July to Oct.  | — Abundant <i>Tripos</i> -plankton, which is sometimes (July 1, 15, Sept. 1) replaced by a neritic <i>Skeletonema</i> -plankton, less frequently mixed with <i>Styli</i> -plankton (Aug. 15). |
| Oct. to Dec.  | — Diminishing Tripos-plankton, <i>Halosphæra viridis</i> .  |
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## General View of the Distribution of the Plankton in the Summer and Autumn.

As it was important to prove the relation in which the various plankton communities stood to the coast itself, the investigations were as far as possible carried out so as to obtain to some extent simultaneous observations out on the coast-banks, in the belt of islands, and inside a fiord. And in order to see how the conditions change with the seasons, these observations were repeated as often as the amount of the government grant permitted.

After the preliminary investigations in 1898, Eids Fiord in Vesteraalen was chosen as the point of departure. This fiord, which is one of our most renowned herring-fiords, lies so close to the open sea, that it does not take long to get from it out to the Vesteraalen edge, where the bottom slopes steeply down to the great depths of the North Atlantic.

Before stating the general results, I will give a short survey of the several investigations, beginning with Eids Fiord and its surroundings, where the most minute investigations were made

Eids Fiord in Vesteraalen, 1898—99.

July 4 & 5, 1899 (Tab. VII).

On July 4th and 5th, 1899, the plankton both inside and outside the fiord, had a pronounced northern character (Tab. VII). Inside the fiord, at Stations E<sub>2</sub> and E<sub>3</sub>, considerable quantities of *Calanus finmarchicus* were found; and of algæ, *Ceratium longipes* and *Peridinium depressum* were found, and in the surface-layers, *Chatoceras criophilum*. The plankton may thus be characterised as a pronounced, and fairly pure, northern

*peridinal plankton*, or *Longipes-plankton*. With large, wide-meshed bags, *Calanus finmarchicus* might be taken in great quantities from the deeper strata; the haul then consisted almost exclusively of this species, though sometimes, too, with large quantities of Ctenophora and a few other northern or arctic forms, such as *Calanus hyperboreus* and *Spadella hamata*.

Just outside the belt of islands (E<sub>4</sub>), and out on the coast-banks, plankton of an altogether different character is found. *Calanus finmarchicus* is here so rare that the quantitative bag did not bring up a single specimen. In its place were found great quantities of diatoms, especially oceanic, northern forms (*Nitzschia delicatissima*), but also some neritic species (*Chaetoceras debile*, *Ch. laciniosum*). Besides the characteristic forms and the neritic species, it also contains some Peridinia, especially *Ceratium longipes* and *Peridinium depressum*.

The *Nitzschia* plankton occurs only as a strip just outside the belt of islands. Near the Vesteraalen edge (Station E<sub>0</sub>), only Peridinia and Crustacea are found — a fairly typical Peridinia-plankton. The northern Styli-plankton, which becomes very abundant later in the summer, is as yet found only in small quantities.

July 17—25, 1899. Table VIII.

During the half month that has passed since the last investigation, conditions have changed. Hydrographic investigations show that some of the cold water that was found in the fiord in the beginning of the month, has been displaced by volumes of salter water, which has flowed in along the bottom. The abundant fauna of northern forms (*Calanus finmarchicus*, *Spadella hamata*) has also been very much reduced; but the surface-plankton in the fiord (St. E<sub>1</sub> and E<sub>2</sub>) has still preserved its northern character, and is still a fairly pure *Longipes-plankton*. At the innermost station there is moreover a neritic *Skeletonema-plankton*.

The *Nitzschia-plankton* has now penetrated to the mouth of Eids Fiord (St. E<sub>3</sub>), where it appears in great quantities. Outside the belt of islands, at St. E<sub>4</sub>, it still predominates at a depth of from 20 to 40 metres; but in the upper strata, down to 20 metres, a southern Peridinia-plankton is found — *Tripes-plankton* —, and deep down, the Styli-plankton begins to assert itself. *Tripes-plankton* is found in the surface-layers over the Vesteraalen edge; and in depths of from 20 to 40 metres, an abundant Styli-plankton.

*Calanus finmarchicus* now has its maximum in the deeper strata at St. E<sub>4</sub>; but otherwise its occurrence is rather scattered.

August, 1899. Table X.

During August, the Longipes-plankton completely disappears, even from the innermost part of the fiord. The characteristic forms, *Ceratium longipes*, *Peridinium depressum*, *P. ovatum*, are indeed still found, but only as minor constituents of the entire plankton. The bulk now consists of the Tripos-plankton's characteristic forms, *Ceratium tripos*, *macroceros*, *fusus*, *furca*, *Peridinium divergens*, *Dinophysis acuta*, *Cyrtarocylis denticulata*, *Oithona similis*, *Microsetella atlantica*.

Inside the fiord, these reign almost alone. On the 26th Aug. at Station E<sub>4</sub>, the Tripos-plankton predominated from the surface down to a depth of 20 metres; but deeper down there is a very abundant Styli-plankton. Over the Vesteraalen edge, the Styli-plankton is almost pure. In August, *Halosphaera viridis* was found only out on the edge; in September it comes right in to the shore.

*Calanus finmarchicus* is very scarce in the fiord, but increases in quantity out towards the Vesteraalen edge.

July to September, 1898. Table V.

In 1898, Eids Fiord still had a pronounced northern peridinal plankton (*Longipes-plankton*) even in the last few days of July. On August 29th, the plankton was very abundant, but it was now southern forms that predominated, especially those species that I have classed as characteristic of the Tripos-plankton of Nordland, but also some that belong to the Styli-plankton. On September 22, 23, the Tripos-plankton still predominates in the fiord (Station E<sub>2</sub>), and at the mouth (E<sub>3</sub>), chiefly Tripos-plankton is found from the surface to a depth of 40 metres, while from 40 to 60 metres down, the Styli-plankton predominates. Outside the fiord, the Styli-plankton is found in large quantities right up to the surface. Just outside the belt of islands (E<sub>4</sub>), great quantities of Peridinia are also found (Tripos-plankton); and farther out, the Styli-plankton is in some measure pure. *Spiralis retroversus* appears in considerable quantities at Station E<sub>6</sub>.

*Calanus finmarchicus* is found in larger numbers outside the belt of islands than inside the fjord, and most numerous out over the Vesteraalen edge.

The actual quantity of plankton, this time as in all the other investigations, is greatest just outside the belt of islands, at Station E4.

On comparing all the four tables, it will be seen that the northern plankton forms remain during the early summer, both in the fiord and out on the coast-banks; but they are replaced gradually by southern species. The change begins from without, and the northern forms hold their ground longer inside the fiords. Where one plankton-community is dislodging another, the new community appears in the deeper layers, while the species that are being displaced are found in the surface-layers. This rule, however, only applies to vegetable plankton; *Calanus finmarchicus* disappears from the surface-layers as they become warmer, and as summer advances, it goes deeper and deeper.

This development shows that the ocean-currents are of great importance to the occurrence of the plankton organisms on the coast. If the coast-waters with all their organisms had been stagnant, the summer heat would have first made itself felt close to land and inside the fiords, and the southern forms would have been able to develop there first. But, leaving out of consideration the uppermost layer close to shore, the heating of the water begins from without, and the southern organisms are not found in the fiord until about a month after their first appearance out over the Vesteraalen edge, and several of them never get into the fiord at all. It must thus be the currents that in the course of the summer alter the character of the plankton, either directly, by bringing southern forms northwards along the coast, or indirectly, by bringing heated water in towards the land, and thereby hastening the development of the local summer forms.

In the belt of islands and just outside it, where the summer plankton is most abundant, the volumes of warm water brought by the coast currents are deepest and greatest.

Neritic forms are scarce outside Eids Fiord; they are partly sub-arctic diatoms, partly larvæ of littoral animal species. Cirripedia larvæ play a conspicuous part in the plankton of the belt of islands, especially in July.

Plankton from Bodø.  
July to October, 1898. Table IV.

A general view of the development of the summer plankton in the belt of islands, is obtained from Table IV. Quite an abundant Longipes-plankton, and some neritic diatoms are found on July 18th on the surface; the deeper strata are more deficient in plankton, but there are a few specimens of *Calanus finmarchicus*. On the 4th August, the southern Peridinia (*Ceratium macroceros*) have displaced the northern; the plankton is abundant in the upper strata, but deep down, where the water is still cold, there is practically hardly any plankton (0.02 grammes in 50—70 metres depth).

By the middle of August, the plankton has become more abundant, the characteristic forms of the Tripos-plankton predominating, such as *Ceratium macroceros* and especially *Acanthometra echinoides*. The unusually great weight of the plankton samples of this time (1.97 gr. Aug. 17) is mainly due to Radiolaria.

Great quantities of *Halosphæra* appear for the first time on September 5th. The Styli-plankton, moreover, has now penetrated farther into the belt of islands; it is rather scarce in the upper strata, but from 40 to 60 metres down, great quantities of *Rhizosolenia alata* are found with auxospores. The sample taken from a depth of 20 metres up to the surface, is the richest I have obtained from Bodø (2.46 gr.); it consists of the characteristic forms of the Tripos-plankton. Among the Peridinia, the predominating species are *Ceratium furca* and *C. bucephalum*.

On the 27th September, the quantity of plankton is already on the decrease. Its character is still Tripos-plankton with the characteristic forms of the Styli-plankton as subordinate parts in its composition.

On October 18th, there is once more rather more plankton. Besides Tripos-plankton and *Halosphæra*, there are some neritic diatoms.

The development at Bodø in 1898, is thus on the whole the same as outside Eids Fiord in 1899. As the investigations at Bodø were made inside the belt of islands, the station may best be compared with Station E3. Nitzschia-plankton was absent from the samples from Bodø, which are especially remarkable for the large quantities of *Acanthometra* in August. Otherwise there are no essential differences.

West Fiord and the Inner Fiords (Ofoten, Tys Fiord) 1898.

Table III.

In July, 1898, the plankton was not very abundant in the outer part of the West Fiord (Station I—III). It consisted for the most part of Peridinia, especially *Ceratium tripos*, *macroceros* and *furca*. Just outside the belt of islands at Bodø (St. I), some diatoms are also found, chiefly oceanic species. *Rhizosolenia alata* is already found here in some abundance. Thus in its character, the plankton agrees best with Tripos-plankton, while Styli-plankton is still at its commencement.

In the innermost part of the West Fiord (Station VI, between Skutvik and Skraaven, St. O<sub>8</sub>, between Barøen and Lødingen), and in the inner fiords, Ofoten and Tys Fiord, the plankton has a more northern character; there are great quantities of *Calanus finmarchicus* and *Ceratium longipes* is the predominating species of Peridinia. The prevailing community is thus Longipes-plankton.

During the first half of August, the condition is still, in the main, unaltered inside the fiords. The quantitative investigations show that there are great quantities of *Calanus finmarchicus* especially at Liland (Station O<sub>8</sub>) in Ofoten. In Tys Fiord there are fewer, especially in the outer part by Korsnes (T<sub>2</sub>); but at Kjøbsvik (T<sub>1</sub>) there are still some in the deeper layers. For the rest, the plankton both in Ofoten and Tys Fiord is pronounced Longipes-plankton.

At the beginning of September, the plankton was very abundant in the lower part of the West Fiord (St. V<sub>1</sub> and V<sub>2</sub>). It consists of southern Peridinia, of *Rhizosolenia alata*, *Halosphaera viridis* and a great number of animals, among which there are numerous larvæ of a siphonophoran, *Physophora borealis*. The character of the plankton is a mixture of Tripos-plankton and Styli-plankton, both communities very abundantly developed. *Calanus finmarchicus* is also found in large quantities, especially younger specimens.

In Ofoten, investigations were repeated on the 25th September when the plankton had already become much poorer than it had been in August. *Calanus finmarchicus* was still found not infrequently, especially at Liland; but at this time of year, it is more numerous outside the belt of islands than in the fiords. Of the remaining organisms, *Ceratium longipes* is still predominant in one of the samples from Liland (40—60

m.); but otherwise the southern *Peridinia* are at any rate fully as common (*Ceratium tripos* and *macroceros*).

Ofoten,

July 28th, 1899. Table IX.\*)

The investigations which I carried out in Ofoten in 1899, I made for the purpose of finding out whether *Calanus finmarchicus* occurred in the same manner as in 1898. It appeared that it was found in great quantities, as in July and August, 1898. I have already mentioned this circumstance more particularly in my discussion of this species above. The other component parts of the plankton are also, on the whole, the same as in 1898; most of them belong to the Longipes-plankton. There are almost no neritic forms found inside the fiords, with the exception of *Skeletonema costatum* and various forms of the genus *Tintinnopsis*. Out at the mouth of the fiord, however, abreast of Lødingen (St. O<sub>8</sub>), there are also some neritic diatoms. The occurrence of the oceanic, northern diatoms, *Chetoceras criophilum* and *decipiens*, which I have mentioned above (page 62), is quite peculiar.

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The investigations in the West Fiord and its innermost branches show the same results as the study of the Eids Fiord plankton. The open part of the West Fiord has almost the same plankton as the coast banks outside, as the water is in unimpeded communication with the currents along the coast. But in the innner fiords, the water is much stiller.

We saw that the northern plankton remained in Eids Fiord all through July, while outside, on the coast-banks, there were southern forms. But in August, some at any rate of these had also penetrated into the fiord, which thus came to have a very rich plankton. The northern forms, in the mean time, decreased in number.

This change in the character of the plankton takes place much more slowly in a deep fiord like Ofoten than in Eids Fiord. On July 28th, 1899, when the Longipes-plankton with *Calanus finmarchicus* had already

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\*) By a mistake, August appears in the table instead of July.

greatly decreased in Eids Fiord, it was still found unmixed and in great quantities in Ofoten. As already mentioned, it was still found there, in 1898, in the middle of August, and even at the end of September it had not altogether disappeared, and only very few of the southern forms were found, which lived at the same time out on the coast-banks

It would thus appear that the abundant plankton that is characteristic of the coast-banks in the summer and autumn, has not time to get into Ofoten before it decreases in abundance when the water cools down in the autumn.

Autumn Plankton from the Fiords in the Northernmost  
Part of Norway.

Table VI.

In October, my assistant, *Henrik Pedersen*, collected some plankton samples in the inner arms of Asta Fiord in the province of Tromsø, and in Øx Fiord in Finmark. Both places had the greatest abundance of neritic diatoms in their plankton, that I have ever found in northern Norway either in the summer or autumn. This neritic diatom community, which I have named the Contorto-plankton, I have mentioned at greater length above.

Among the neritic species, there are also some oceanic diatoms. In the branches of Asta Fiord (Gra Fiord, Gratangen, Salangen) these are especially *Nitzschia delicatissima*, *Chaetoceras decipiens*, and *Thalassiothrix Fraunfeldii*, all northern forms. In Øx Fiord, on the other hand, it is the characteristic forms of the Styli-plankton that accompany the neritic diatoms (*Rhizosolenia alata*, *styliiformis*, *Shrubsolei*, *Stolterfothii*); the neritic species also have a somewhat more southern character, *Chaetoceras curvisetum*, for instance, being found only in Øx Fiord.

With regard to the reason of this peculiar circumstance, nothing can as yet be said, as there have been no simultaneous investigations of the coast-banks outside the fiords.

The reason why there is a more abundant neritic plankton in the most northerly parts of Norway than in Nordland, is probably that in the north there are larger tracts of shallow water.

If we now compare the results of all these investigations, we shall see that the plankton along the coast changes in the course of the the summer, and the change begins out on the coast-banks, then comes in to the belt of islands, but does not assert itself in the fiords until much later, sometimes not at all.

As I have already said, this is a proof that the changes are contingent on ocean currents, which are continually bringing fresh volumes of water in to the coast. The water in which great quantities of *Calanus finmarchicus* and northern Peridinia (Longipes-plankton) live, is found about the belt of islands in May and June; in July, the same species only live in the fiords, while the island-belt has first a Nitzschia plankton, then plankton communities of more southern origin, Tripos-plankton and Styli-plankton. Tripos-plankton is not found, for instance, in Eids Fiord until August. Styli-plankton seldom comes into the fiord.

It does not necessarily follow from this that the greater proportion of the plankton organisms of the coast-waters are only visitors that come in with the volumes of water from neighbouring or distant regions. The influence of ocean currents may also be indirect; the warm water which they bring northwards every summer, may awaken to growth and propagation the scanty fauna and flora that has survived the winter along the coast, either in quiescent stages on the bottom, or as solitary free-floating individuals in the fiords.

It is probable that the ocean currents act both directly and indirectly in enriching the plankton of the coast-waters; and many investigations will still be needed to decide how large a proportion of the plankton comes in from without, and how much develops from the coast-water itself. For the present, it can only be affirmed that the ocean currents are of decisive importance.

In 1898 and 1899, the periodic changes of the plankton seem to have taken place on the whole in the same manner. Nitzschia-plankton was not observed in 1898; but the investigations were not begun that year until the 15th July, and it is therefore possible that it has been near the coast, but had disappeared before the commencement of the investigations. Another minor difference is that the Styli-plankton (*Rhizosolenia alata*, etc.) in 1898, seems to have had its maximum in September, while in 1899, it occurred in greatest abundance in August, and in September was already diminishing in the belt of islands.

In 1895, on the other hand, the change seems to have taken place in a somewhat different manner, as will be seen from *Hjort's* samples (*Hjort & Gran* [99], Tab. 1). The working-up of the samples was done in 1896, before the results of most of the investigations of subsequent years were published. I could not therefore take notice of the various forms that have since been separated, especially among the *Peridinia*. I have therefore again gone through some samples, and here append the contents of some of the most important.

The two sections Bodø — Røst — Vesteraal's edge, on July 9, 10, and Aug. 28 to Sept. 3 are the most important. The subjoined table (page 83) shows the composition of the plankton at 5 selected stations. Stations 15, 16 and 37 lie west of Røst, 18 and 34 in the lower part of the West Fiord.

It will be seen from this that the *Styli*-plankton was found in great quantities as early as the first half of July, and in August and September it had greatly diminished. The northern *Longipes*-plankton has practically disappeared in July, and only small quantities of *Nitzschia*-plankton are found just outside Røst at Station 16. The characteristic forms of the *Tripes*-plankton are found in great quantities both in July and in September, *Ceratium tripos* var. *bucephala* being especially plentiful in September, as also *Dinophysis acuta*.

The various plankton communities appeared in 1895 in about the same consecutive order as in 1898 and 1899, but in 1895 they were found earlier in the year. The abundant *Styli*-plankton seems to have had its maximum 1 or 2 months earlier in 1895 than in 1898 and 1899.

The causes of this difference are not at present known. It may perhaps have something to do with the circumstance that in the summer of 1895 there seems to have been a more abundant flow of salt oceanic water to the coast than in the last two years. This is a matter which ought to be more carefully examined into; for if these variations can be explained, we shall have come very much nearer to a comprehension of the vital conditions of the organisms in the coast-waters.

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	St. 15. July 9, '95. N. 67° 31' E. 10° 41.5'		St. 16. July 9, '95 N. 67° 26' E. 12° 30'		St. 18. July 10, '95 N. 67° 20' E. 13° 54'		St. 37. Sept. 10, '95 N. 67° 56' E. 10° 14'		St. 34. Aug. 28, '95 N. 67° 29' E. 13° 8.5'	
	0 m.	0-50 m.	0 m.	0-50 m.	0 m.	0-50 m.	0 m.	0-50 m.	0 m.	0-50 m.
<i>Chaetoceras boreale</i> .....	.	.	r	r	.	.	.	.	.	.
— <i>decipiens</i> .....	.	.	r	r	.	.	.	.	.	.
<i>Coccinodiscus polychordus</i>	.	.	.	+	.	.	.	.	.	.
<i>Nitzschia delicatissima</i> ....	.	.	.	+	.	.	.	.	.	.
— <i>seriata</i> .....	.	.	.	e	.	.	.	.	.	.
<i>Rhizosolenia alata</i> .....	e	ee	e	ee	ee	r	e	+	r	r
— <i>Shrubsolei</i> .....	.	+	.	+	r	.	.	.	.	.
— <i>styliformis</i> .....	.	r	.	e	.	.	.	.	.	.
<i>Ceratium furca</i> .....	+	e	+	e	+	r	+	.	.	+
— <i>fuscus</i> .....	e	e	e	e	+	r	e	.	+	.
— <i>tripos</i> .....	ee	ee	ee	ee	ee	+	ee	+	+	.
— <i>v. bucephala</i> ....	+	+	.	.	.	.	ee	+	ee	+
— <i>» longipes</i> .....	+	+	e	e	.	.	.	.	.	.
— <i>» macroceros</i> ...	+	ee	e	e	ee	.	e	.	+	.
<i>Dinophysis acuta</i> .....	r	e	.	.	r	.	.	e	.	ee
— <i>Michaëlis</i> .....	.	r	.	.	.	.	.	.	.	+
<i>Diplopsalis lenticula</i> .....	.	r	.	.	.	.	.	+	.	r
<i>Peridinium divergens</i> ....	r	+	+	.	+	.	.	+	.	+
— — <i>v. conica</i> .....	.	+	r	+	.	.	.	.	.	.
— — <i>» depressa</i> ....	.	e	e	+	e	+	+	+	.	+
— <i>Michaëlis</i> .....	.	r	.	.	.	.	.	.	.	r
— <i>ovatum</i> .....	.	e	.	+	.	.	.	.	.	.
— <i>pellucidum</i> .....	.	r	.	.	.	.	.	.	.	r
<i>Amphorella Steenstrupii</i> ..	.	.	.	.	.	.	.	r	.	r
<i>Cyttarocylis denticulata</i> ..	+	e	+	e	e	r	.	.	.	.
<i>Tintinnus acuminatus</i> ....	.	r	.	.	.	.	.	.	.	r
<i>Acanthometra echinoides</i> .	.	.	.	.	.	.	.	.	r	.
<i>Globigerina bulloides</i> .....	.	.	.	.	.	.	.	r	.	r
<i>Calanus finmarchicus</i> .....	.	.	.	.	.	.	r	+	.	.
<i>Microsetella atlantica</i> ....	.	r	.	.	ee	+	.	.	.	.
<i>Oithona similis</i> .....	r	r	.	r	e	r	r	.	ee	r
<i>Pseudocalanus elongatus</i> .	.	r	.	.	.	.	+	.	ee	r
<i>Evadne Nordmanni</i> .....	.	r	r	.	+	r	.	.	+	r

The general results that can be drawn from my investigations of the coast-plankton of Nordland, may be summed up as follows:

1. Neritic organisms in the narrower sense, are only found in small quantities on the coast of Nordland, even if the number of neritic species is not inconsiderable. Some of the neritic forms are arctic and vegetate in the plankton, principally in April, some sub-arctic, with their maximum in September and October. The bulk of the plankton consists of oceanic organisms.
2. Some of these oceanic organisms must be regarded as visitors from the North Atlantic. They come from without over the coast-banks, but seldom go farther in than to the belt of islands, e. g. *Nitzschia*-plankton, *Styli*-plankton.
3. The various organisms or communities of organisms have their maxima near the coast in the same consecutive order, and about the same season of the year, in the different years. Changes in the composition of the plankton first appear out on the banks, then in the belt of islands, and lastly in the fiords.
4. The greater part of the plankton is formed of such oceanic organisms (*Peridinia*, *Crustacea*) as are found along the coast all the year round, but in small quantities. At certain fixed times of the year, the individual number of each species is greatly increased, partly perhaps by multiplication of the local stock, but probably also by an influx from without.

All these species have a very wide distribution. The species belong to two rather clearly separated communities, a northern *Peridinia*-plankton (*Longipes*-plankton), and a southern plankton (*Tripes*-plankton).

5. The characteristic forms of the northern *Peridinia*-plankton are *Ceratium tripos* var. *longipes*, *Peridinium divergens* v. *depressa*, *Peridinium ovatum*, and of animals, *Calanus finmarchicus*.

These forms have their maximum outside the belt of islands in May and June, in the fiords in July, and in the deepest water late in August.

6. The southern *Peridinia*-plankton (characteristic forms, *Ceratium tripos* var. *genuina* and var. *macroceros*, *Cyttarocyis denticulata*, *Oithona*

*similis*, *Microsetella atlantica*) is found outside the belt of islands most abundantly from July to October, in the fiords in August and September.

7. The actual quantity of plankton is greatest as a rule between the islands in the belt, and just beyond them. From the belt of islands, it decreases both outwards towards the open sea, and inwards in the fiords.
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### **III. Connection between Hydrographic and Biological Conditions.**

It appears from the foregoing that the distribution of the organisms in the coast-water is closely connected with the hydrographic conditions. But the matter is exceedingly complicated, and not yet by any means cleared up. As the investigations are still to be continued, I will here only give a short account of the knowledge we at present possess towards the solution of the principal questions.

The problems that have been the special object of my researches, and which must continue to be studied in the immediate future, may be summed up in the two following principal questions:

1. Can any conclusions be drawn from the composition of the coast-plankton, as to the origin of the volumes of water that move in towards and along the northern shores of Norway?
2. Can the current-system of the North Atlantic have such an effect upon the hydrographic and biological character of the coast-water, that it can influence the wanderings of the summer herring, and directly or indirectly produce the great irregularities in the in-pouring, that occur from year to year?

Neither of these questions can yet be fully answered, but there are various circumstances which indicate that with continued, more comprehensive investigations, there will be a possibility of coming to a satisfactory solution.

#### **I. The Geographical Origin of the Coast-Plankton.**

As mentioned above, the coast-plankton of Nordland consists partly of southern, partly of northern forms. Most of these may remain on the

coast all the year round, at any rate in small quantities; but the local supply seems at any rate to be renewed to a large extent by influx from without.

The southern forms appear especially in the summer and autumn. The most important plankton communities with a southern character are the Tripos-plankton (page 65) and the Styli-plankton (page 62). These two communities make up the greater part of the summer and autumn plankton of the coast-water, and they show a resemblance both to the summer plankton of the Gulf Stream, and to the plankton community that is found at the same season of the year on the shores of the North Sea, especially the coast of Norway. It is not as yet possible to make out how many of these southern forms are stationary by the coast, and how many of them come north every summer with the coast-currents from Norway's west coast, or with the Gulf Stream. This much may be said with certainty, namely, that a great part of the abundant plankton that is to be found above the coast-banks of Nordland in the summer, is of foreign, southern origin; and even the organisms that develop on the spot, must be accelerated in their development by the improved vital conditions produced by the volumes of warm water from the south.

The northern organisms are found in greatest quantities from March to June, in the fiords sometimes up to July. They form several natural plankton communities, of which the most important is the northern Peridinia-plankton, or Longipes-plankton. The Longipes-plankton on the coast of Nordland agrees accurately in its composition with a similar community, which according to *Ostenfeld's* investigations, is characteristic of the east Icelandic polar current in the summer. This agreement indicates that there may be a direct connection between the water of the polar current and the coast-water off Nordland, even if this biological accordance does not constitute any decisive proof. The question has not yet been investigated as to the distribution of these organisms over the North Atlantic at that season (March to May), when they might be assumed to drift from the polar current into the Norwegian coast-water. But, as I have mentioned more fully in the first section (page 9), there are several circumstances which indicate that the water of the east Icelandic polar current at the coldest time of the year, may be in direct communication with the Norwegian coast-water off Stadt, and that probably the water of the polar current unites all the year through with that portion of the

Gulf Stream which moves from the Faro and Shetland channel north-east to northern Norway and Spitsbergen.

The northern plankton organisms, which fill the Norwegian coast-waters in the spring months, are therefore undoubtedly biologically dependent upon the polar current having shortly before had its annual maximum, even if they do not from a geographical point of view, require to originate from the north-west part of the North Atlantic. This last is especially applicable to the arctic neritic diatoms (Tænio-plankton, cf. page 57), which in all probability are stationary near the coast, where they may be supposed to rest upon the bottom all the year round, but which are only found in the plankton in March and April, when the coast-water has its annual temperature-minimum.

In the summer, the cold volumes of water that remain in the fiords, may be known by their arctic organisms (Longipes-plankton). As the water is gradually driven out, the greater part of the organisms also disappear.

If the results are employed with caution, the plankton investigations may therefore afford valuable hints as to the origin of the water.

## 2. The In-Pouring of the Summer Herring.

The investigations made up to the present are altogether insufficient to allow of a well-founded opinion being formed with regard to the irregularity in the influx of herring. Sars has found that the herring lives on the organisms found in the coast-water in the summer (*Calanus finmarchicus*, *Boreophausia inermis*, *Spiralis retroversus*), and he brought forward the theory that the in-pouring takes place because there is a much more abundant animal life on the coast-banks than out in the open sea. My own researches (cf. page 69) also confirm the theory that the actual quantity of plankton decreases from the belt of islands out towards the open sea.

Hereby, however, Sars's theory is not yet proved, however reasonable it may seem. And if it is correct, it will still be difficult to understand that variations in the distribution of the plankton organisms should in themselves be the cause of the herring one year coming to land in great shoals, and the following year only in comparatively small numbers, and perhaps at altogether different places.

In the summer of 1898, very little herring was found on the coast of Nordland. In the latter half of July and the beginning of August, however, some was fished, especially in Ofoten and the upper part of the West Fiord. The simultaneous plankton investigations showed that just at these places, considerable quantities of *Calanus finmarchicus* were found. In other places, on the other hand, where there was no fishing worth mentioning, e. g. Tys Fiord and Eids Fiord, *Calanus finmarchicus* was scarce, and other rather larger plankton organisms were not found either. Later in the autumn, the number of *Calanus* decreased in Ofoten, while at the same time the herring-fisheries also gradually ceased. The last herring were caught in a net among the sea-weed close up to land, where they had probably been seeking their food among litoral organisms. On another occasion, I found remains of bottom animals in the stomach of some herrings that had been taken in a net close to shore.

These observations agree with Sars's view that the herring, at the time of its in-pouring, seeks those places where there is most food; but this does not bring us much nearer to a comprehension of the causes of the pouring-in itself.

It is, however, highly probable that the current-conditions in the North Atlantic may be of the greatest significance both for the development and distribution of the plankton organisms, and thereby for the herring's migrations; but the circumstances are so complicated that regular investigations will be required for a number of successive years, if any decisive results are to be obtained. In 1898 and 1899, when my investigations were carried out, the herring-fisheries in Nordland were a failure; therefore from these investigations alone, no conclusions can be drawn as to the causes of the in-pouring of the herring; but it is to be hoped that they will nevertheless have some importance as a link in the chain of investigations that are to be carried out in this problem.

Christiania. April, 1900.



## Bibliography.

96. **Aurivillius, C. W. S.** Das Plankton der Baffins Bay und Davis Strait. 1896. *Festschrift für Liljeborg*.
98. — Vergleichende thiergeographische Untersuchungen über die Planktonformen des Skagerraks in den Jahren 1893—97. 1898. *Kongl. Svenska Vetenskaps-akademiens Handlingar*. B. 30, No. 3.
81. **Bergh, R. S.** Der Organismus der Cilioflagellaten. Eine phylogenetische Studie. 1881. *Morphol. Jahrbuch* Bd. 7. 2.
96. **Brandt, K.** Die Tintinnen. Zoologische Ergebnisse der von der Gesellschaft für Erdkunde zu Berlin unter Leitung Dr. von Drygalski's ausgesandten Grönlandexpedition nach Dr. Vanhöffens Sammlungen bearbeitet. 1896. *Bibliotheca Zoologica*. Heft. 20. Lfg. 2.
98. — Beiträge zur Kenntniss der chemischen Zusammensetzung des Planktons. 1898. *Wissenschaftliche Meeresuntersuchungen* Bd. 3. Abtheilung Kiel.
96. **Cleve, P. T.** Vegetabiliskt Plankton. 1896. *Bihang til kongl. Svenska Vetenskaps-akademiens Handlingar*. B. 22. Afd. III. No. 5.
97. — A Treatise on the Phytoplankton of the Northern Atlantic and its Tributaries. 1897.
- 99,1. — Plankton collected by The Swedish Expedition to Spitzbergen in 1898. 1899. *K. Svenska Vet. Ak. Hand. Bd. 32. No. 3.*
- 99,2. — On the seasonal distribution of some Atlantic plankton-organisms. 1899. *Öfversigt af Kongl. Vet.-Ak. Förhandlingar 1899. No. 8.*
- 99,3. — On the origin of «Gulf-Stream-water». *Ibidem 1899, No. 3.*
- 99,4. — Plankton-Researches in 1897. 1899. *K. Sv. Vet. Ak. Handl. Bd. 32. No. 7.*
00. — The Plankton of the North Sea, the English Channel, and the Skagerrak in 1898. 1900. *Ibidem Bd. 32. No. 8.*
94. **Gade.** Temperaturmaalinger i Lofoten 1891—92. Christiania 1894. Udgivet efter Foranstaltning af Departementet for det Indre.
- 97,1. **Gran, H. H.** Protophyta: Diatomaceæ, Cilioflagellata og Silicoflagellata. 1897. *Den norske Nordhavs-Expedition 1876—78. Hefte 24.*
- 97,2. — Bacillariaceen aus dem kleinen Karajakfjord. 1897. *Bibliotheca botanica. Hefte 42.*
- 97,3. — Bemerkungen über das Plankton des Arktischen Meeres. 1897. *Berichte der Deutschen Botanischen Gesellschaft. B. XV.*
00. — Bemerkungen über einige Planktondiatomeen. 1900. *Nyt Magazin for Naturvidenskaberne. Bd. 38, Hefte 2.*
90. **Häckel, Ernst.** Plankton-Studien. Jena 1890.

97. **Hjort, Johan.** Undersøgelser over organismerne og strømforholdene i det norske Nordhav. *Naturen* 1897.
99. **Hjort, Johan and Gran, M. H.** Currents and Pelagic Life in the Northern Ocean. 1899. *Bergens Museums Skrifter. Vol. VI.*
00. — — Hydrographic-Biological Investigations of the Skagerrak and the Christiania Fiord. 1900. *This volume, No. 2.*
99. **Jørgensen, E.** Ueber die Tintinnodeen der norwegischen Westküste. *Bergens Museums Aarbog* 1899.
98. **Knudsen, Martin.** Hydrografi. 1898. *Den danske Ingolf-Expedition. Bd. I, 1.*
99. **Knudsen, M. og Ostenfeld, C.** Iagttagelser over Overfladevandets Temperatur, Saltholdighed og Plankton paa islandske og grønlandske Skibsruter i 1898. København 1899.
96. **Lagerheim, G. v.** Ueber Phæocystis Poucheti (Har.) Lagerh., eine Plankton-Flagellate. 1896. *Øversigt af K. Vet. Ak. Förhandl. 1896. No. 3.*
99. **Lemmermann, E.** Ergebnisse einer Reise nach dem Pacific (H. Schauinsland 1896/97). Planktonalgen. 1899. *Abh. Nat. Ver. Brem. Bd. XVI, Heft 2.*
87. **Mohn, H.** The North Ocean, its Depths, Temperature and Circulation. 1887. *The Norwegian North-Atlantic Expedition. 1876—78.*
99. **Nordgaard, O.** Contribution to the Study of Hydrography and Biology on the Coast of Norway, 1899. *Bergens Museums Skrifter, Vol. VI.*
00. — Træk af Fjordenes og Kystens Hydrografi. 1900. *Norsk Fiskeritidende 1900, 1. Hefte.*
98. **Ostenfeld**, see **Wandel & Ostenfeld.**
99. — , see **Knudsen & Ostenfeld.**
98. **Petersen, C. G. Joh.** Planktonstudier i Limfjorden. 1898. *Beretning til Indenrigsministeriet fra Den danske biologiske Station.*
99. **Pettersen, O.** Ueber den Einfluss der Eisschmelzung auf die Oceanische Circulation. 1899. *Øversigt af Kongl. Vet.-Ak. Förhandl. 1899. No. 3.*
00. — Die hydrographischen Untersuchungen des Nordatlantischen Ozeans in den Jahren 1895—96. *Dr. A. Petermanns Geogr. Mittheilungen 1900, Heft I & II.*
91. **Pettersen, O. och Ekman, G.** Grunddragen af Skagerracks och Kattegats Hydrografi. 1891. *Kongl. Svenska Vetenskaps-Akademiens Handlingar. B. 24, No. 11.*
98. — — Die hydrographischen Verhältnisse der oberen Wasserschichten des Nördlichen Nordmeeres zwischen Spitzbergen, Grönland und der norwegischen Küste in den Jahren 1896 und 1897. 1898. *Bihang till K. Sv. Vet.-Ak. Handl. B. 23. Afd. I, No. 4.*
92. **Schütt, Fr.** Analytische Plankton-Studien. Kiel u. Leipzig 1892.
93. — Das Pflanzenleben der Hochsee. Kiel u. Leipzig 1893.
80. **Tørnøe, H.** Chemistry, 1880. *The Norwegian North-Atlantic Expedition 1876—78.*
98. **Wandel, C. F.** Reiseberetning. 1898. *Den danske Ingolf-Expedition. Bd. I, 1.*
99. — Current Bottles. 1899. *Ibidem Bd. I, 2.*
98. **Wandel, C. F. og Ostenfeld, C.** Iagttagelser over Overfladevandets Temperatur, Saltholdighed og Plankton paa islandske og grønlandske Skibsruter i 1897. København 1898.

# HYDROGRAPHICAL TABLES



## Remarks on the Hydrographical Tables.

(From information supplied by Mr. S. Schmidt-Nielsen).

The determination of the salinity of the samples of water was made by the titration of 10 cem, with  $\frac{1}{8}$  normal solution of nitrate of silver, and with chromate of potassium as an indicator.

From the amount of chlorine (Halogen) discovered, the salinity has been calculated as salt ‰, according to the data given by Pettersson and Ekman [91].

The chlorine titration of the solution of nitrate of silver has not been fixed by the introduction of small portions of pure chloride of sodium, but by a solution of chloride of a known strength.

Such a solution of chloride was constantly employed for controlling purposes during the analyses, in order to eliminate, so far as possible, the errors which arise from the calibration of the pipettes and burettes, and the analyst's method of procedure while making the observations.

In order that the results arrived at can be compared with those obtained by other hydrographers, a common sea water solution, «Standard», was adopted and agreed upon, by arrangement with Professor O. Pettersson in Stockholm, in December 1898, as a basis for the determination of chloride. The «Standard, 1899» was prepared at the High School at Stockholm, and distributed to the various hydrographers. Its titration has been carried out by weight-analyses made, independently, by Swedish and Norwegian hydrographers.

At the same time the «Standard» was introduced, it was agreed that, until further notice, the Manuscript Tables, compiled by Pettersson for the purpose, should be employed in calculating the amount of salt ‰. All the Analyses given here, refer to «Standard 1899».

The samples collected in 1898 (Tables I–II) were analysed by Mr. S. Schmidt-Nielsen; those of 1899 (Table III) by the Author.

Pettersson's isolating water fetchers, except where otherwise stated, were employed in procuring the samples of water from the depth, and observations of the temperature.



**I. Northern Ocean. 1897—98.**



# VII

## I. Northern Ocean. 1897—98.

Station	March 1897		N. Latitude	E. Longitude	Temperature of the surface water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt pea mille	

### 1. Norway—Iceland. March 1897, Capt. Foden.

(Surface observations).

					° C.				
3	12 noon.	57° 51' N.	6° 9' E.		4.5	19.84	35.86	34.95	
	4 p. m.	58° 4'	5° 15'		5.5	20.09	36.30	35.86	
	8 —	58° 18'	4° 26'		5.5	20.12	36.36	35.46	
	12 night.	58° 30'	3° 37'		5.5	20.19	36.53	35.57	
4	4 a. m.	58° 44'	2° 46'		5.5	20.09	36.30	35.36	
	8 —	58° 57'	1° 55'		5.0	20.09	36.30	35.36	
	10 —	59° 4'	1° 29'		5.0				
	12 noon.	59° 13'	0° 56'		5.5	20.16	36.43	35.52	
	2 p. m.	59° 16'	0° 26'		5.5				
	4 —	59° 19'	0° 4' W.		6.0	20.30	36.68	35.71	
	6 —	59° 22'	0° 38'		6.0				
	8 —	59° 25'	1° 10'		6.5	20.26	36.61	35.64	
	10 —	59° 26'	1° 41'		6.5				
	12 night.	59° 32'	2° 10'		6.0	20.19	36.48	35.57	
5	2 a. m.	59° 39'	2° 42'		6.0				
	4 —	59° 46'	3° 12'		6.0	20.23	36.56	35.59	
	6 —	59° 53'	3° 43'		7.0				
	8 —	60° 2'	4° 22'		7.5	20.30	36.68	35.71	
	10 —	60° 7'	4° 50'		8.5				
	12 noon.	60° 11'	5° 14'		8.0	20.12	36.36	35.46	
	2 p. m.	60° 16'	5° 46'		7.5				
	4 —	60° 20'	6° 20'		8.0	20.30	36.68	35.71	
	6 —	60° 25'	6° 52'		7.5				
	8 —	60° 29'	7° 24'		7.5	20.33	36.73	35.76	
6	10 —	60° 33'	7° 54'		7.5				
	12 night.	60° 36'	8° 24'		7.5	20.26	36.61	35.64	
	2 a. m.	60° 40'	8° 54'		7.5				
	4 —	60° 44'	9° 24'		7.0	20.26	36.61	35.64	
	6 —	60° 48'	9° 52'		7.5				
	8 —	60° 51'	10° 18'		7.5	20.26	36.61	35.64	
	10 —	60° 54'	10° 40'		7.5				
	12 noon.	60° 54'	10° 50'		7.5	20.26	36.61	35.64	
	4 p. m.	61° 0'	11° 12'		7.5				
	6 —	61° 7'	11° 41'		7.5	20.26	36.61	35.64	
7	8 —	61° 14'	12° 12'		7.5				
	10 —	61° 21'	12° 40'		7.5	20.23	36.56	35.59	
	12 night.	61° 28'	13° 12'		7.5				
	2 a. m.	61° 36'	13° 44'		7.5	20.23	36.56	35.59	
	4 —	61° 44'	14° 14'		7.5				
	6 —	61° 52'	14° 46'		7.5	20.19	36.48	35.57	
	8 —	61° 59'	15° 16'		7.5				
	10 —	62° 6'	15° 48'		8.0	20.19	36.48	35.57	
	12 noon.	62° 14'	16° 19'		8.0				
	2 p. m.	62° 22'	16° 50'		8.0	20.19	36.48	35.57	
	4 —	62° 31'	17° 20'		8.0				
	6 —	62° 39'	17° 50'		8.0	20.16	36.43	35.53	
	8 —	62° 47'	18° 19'		8.0				
	10 —	62° 54'	18° 48'		8.0	20.19	36.48	35.57	

## VIII

Station	March 1897		N. Latitude	W. Longitude	Temperature of the surface water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
7 8	12	night.	63° 2' N.	19° 18' W.	° C				
	2	a. m.	63° 8'	19° 42'	7.5				
	4	—	63° 14'	20° 5'	7.0	20.16	36.43	35.52	
	6	—	63° 20'	20° 28'	7.0	20.23	36.56	35.59	
	8	—	63° 21'	20° 42'	6.5				
	10	—	63° 26'	21° 10'	6.3	20.23	36.56	35.59	
	12	noon.	63° 31'	21° 38'	6.3				
	2	p. m.	63° 39'	22° 10'	6.3	20.23	36.56	35.59	
	4	—	63° 47'	22° 44'	6.0				
	6	—	64° 1'	23° 7'	5.0	20.19	36.48	35.53	
	8	—	64° 15'	23° 25'	5.0				
	10	—	64° 29'	23° 48'	5.0	20.12	36.36	35.46	
	12	night.	64° 43'	24° 0'	4.5				
	2	a. m.	64° 58'	24° 16'	3.5	19.91	35.99	35.07	
9	4	—	65° 14'	24° 30'	2.0				
	6	—	65° 30'	24° 37'	2.0	19.63	35.51	34.61	
	8	—	65° 44'	24° 18'	1.0				
	10	—	65° 57'	23° 52'	0.5	20.12	36.36	35.46	

2. Utsire—Jan Mayen March 1898, <sup>s</sup><sub>s</sub> Westbye Egeberg.

Capt. L. Tufte.

Surface Observations.

1898 March		Hour	N. Latitude	E. Longitude	° C.			
Date								
5	12	night.	59° 36' N.	4° 37' E.	4.5	19.35	34.98	34.12
6	3	a. m.	59° 50'	4° 25'	5.0	19.44	35.14	34.26
	7	—	60° 6'	4° 16'	5.75	19.76	35.72	34.80
	10 <sup>1</sup> / <sub>2</sub>	—	60° 21'	4° 10'	7.0	19.92	36.01	35.09
	2	p. m.	60° 37'	4° 3'	6.5	19.83	35.85	34.93
	8	—	60° 51'	3° 56'	6.0	19.80	35.79	34.88
7	7	a. m.	61° 5'	3° 48'	7.0	19.72	35.65	34.76
	10 <sup>1</sup> / <sub>2</sub>	—	61° 19'	3° 41'	7.25	19.92	36.01	35.09
	2	p. m.	61° 33'	3° 34'	7.5	20.00	36.14	35.21
	5	—	61° 47'	3° 28'	7.0	19.83	35.85	34.98
	8	—	62° 2'	3° 22'	7.0	19.92	36.01	35.09
	11	—	62° 17'	3° 18'	7.0	20.04	36.21	35.28
8	2	a. m.	62° 32'	3° 15'	7.25	20.08	36.28	35.35
	5	—	62° 47'	3° 12'	6.5	20.00	36.14	35.21
	8	—	63° 2'	3° 9'	6.5	20.00	36.14	35.21
	11 <sup>1</sup> / <sub>2</sub>	—	63° 26'	3° 6'	6.5	20.00	36.14	35.21
	3	p. m.	63° 40'	3° 0'	6.5	20.00	36.14	35.21
	6	—	63° 55'	2° 56'	5.5	19.88	35.93	35.01
	8 <sup>1</sup> / <sub>4</sub>	—	64° 10'	2° 53'	5.5	19.96	36.07	35.15
	10 <sup>3</sup> / <sub>4</sub>	—	64° 25'	2° 50'	5.25	19.92	36.01	35.09
9	1 <sup>1</sup> / <sub>2</sub>	a. m.	64° 40'	2° 47'	4.75	19.76	35.72	34.80
	3 <sup>1</sup> / <sub>2</sub>	—	64° 55'	2° 43'	5.25	19.83	35.85	34.93
	6	—	65° 10'	2° 40'	4.0	19.76	35.72	34.80
	8	—	65° 25'	2° 36'	4.75	20.00	36.14	35.21
	10	—	65° 40'	2° 32'	5.5	19.92	36.01	35.09
	12	noon.	66° 7'	2° 22'	5.75	19.96	36.07	35.15
	2 <sup>1</sup> / <sub>4</sub>	p. m.	66° 22'	2° 17'	5.5	19.96	36.07	35.15

Station	March 1898		N. Latitude	E. Longitude	Temperature of the surface water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
	9	4 1/2 p. m.	66° 37' N.	2° 11' E.	5.5	19.92	36.01	35.09	
		6 1/2 —	66° 52'	2° 6'	4.5	19.92	36.01	35.09	
		9 —	67° 6'	2° 0'	5.5	19.92	36.01	35.09	
		11 1/2 —	67° 21'	1° 54'	5.25	19.83	35.85	34.98	
	10	2 a. m.	67° 35'	1° 48'	5.25	19.89	35.96	35.04	
		5 —	67° 50'	1° 44'	5.25	19.92	36.01	35.09	
		8 —	68° 4'	1° 40'	5.25	19.92	36.01	35.09	
		10 1/4 —	68° 16'	1° 37'	5.25	19.89	35.96	35.04	
		2 p. m.	68° 31'	1° 40'	3.75	19.92	36.01	35.09	
		5 —	68° 46'	1° 44'	3.75	19.92	36.01	35.09	
		8 —	69° 1'	1° 48'	3.75	19.92	36.01	35.09	
		12 —	69° 16'	1° 56'	3.0	19.92	36.01	35.09	
	11	4 a. m.	69° 31'	2° 0'	3.25	19.92	36.01	35.09	
		12 noon.	69° 51'	2° 4'	4.0	19.92	36.01	35.09	
		3 p. m.	70° 4'	1° 40'	3.5	19.92	36.01	35.09	
		5 —	70° 18'	1° 25'	3.25	19.92	36.01	35.09	
		7 —	70° 31'	1° 14'	3.0	19.92	36.01	35.09	
		9 —	70° 47'	0° 55'	3.25	19.89	35.96	35.04	
		11 —	71° 0'	0° 40'	3.25	19.89	35.96	35.04	
	12	2 a. m.	71° 14'	0° 25'	2.25	19.83	35.85	34.98	
		5 1/2 —	71° 30'	0° 15'	2.75	19.83	35.85	34.98	
		9 —	71° 45'	0° 10'	0.75	19.80	35.79	34.88	
		2 1/2 p. m.	72° 20'	1° 0'	1.5 —	19.89	35.96	35.04	

### 3. Norway—Iceland, March 1898, <sup>s</sup> Heimdal, Capt. H. C. Hansen.

March									
16	12 noon.	57° 53' N.	7° 12' E.	3.0	16.93	30.65	29.98		
	4 p. m.	58° 0'	6° 30'	3.5	16.71	30.26	29.61		
	8 —	58° 9'	5° 57'	5.5	17.00	30.77	30.10		
17	12 night.	58° 18'	5° 23'	4.0	18.09	32.74	31.98		
	4 a. m.	58° 27'	4° 47'	4.0	18.24	33.01	32.24		
	8 —	58° 38'	4° 7'	5.0	19.40	35.10	34.22		
18	12 noon.	58° 49'	3° 23'	6.5	20.08	36.32	35.39		
	4 p. m.	58° 55'	2° 37'	7.0	20.08	36.32	35.39		
	8 —	59° 1'	1° 52'	7.0					
19	12 night.	59° 9'	1° 4'	7.0	20.08	36.32	35.39		
	4 a. m.	59° 15'	0° 15'	7.0	20.08	36.32	35.39		
	8 —	59° 21'	0° 38' W.	7.0	20.11	36.38	35.44		
20	12 noon.	59° 30'	1° 47'	7.0	20.25	36.63	35.68		
	4 p. m.	59° 40'	2° 34'	7.2	20.08	36.32	35.39		
	8 —	59° 50'	3° 17'	7.0	20.27	36.67	35.71		
21	12 night.	59° 58'	3° 56'	7.0	20.25	36.63	35.68		
	4 a. m.	60° 4'	4° 25'	7.5	20.25	36.63	35.68		
	8 —	60° 10'	4° 52'	8.0	20.22	36.58	35.63		
22	12 noon.	60° 15'	5° 19'	7.0	20.22	36.58	35.63		
	4 p. m.	60° 20'	5° 50'	7.3	20.18	36.50	35.56		
	8 —	60° 6'	6° 20'	6.5	20.18	36.50	35.56		
23	12 night.	60° 30'	6° 50'	6.5	20.18	36.50	35.56		
	4 a. m.	60° 35'	7° 23'	6.5	20.18	36.50	35.56		
	8 —	60° 40'	7° 49'	7.2	20.18	36.50	35.56		
24	12 noon.	60° 44'	8° 14'	7.2	20.15	36.45	35.51		
	4 p. m.	60° 25'	8° 54'	7.0	20.32	36.75	35.80		

Station	March 1898		N. Latitude	W. Longitude	Temperature of the surface water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
					° C.				
	20	8 p. m.	61° 0' N.	9° 36' W.	7.0	20.15	36.45	35.51	
		12 night.	61° 9'	10° 22'	7.0	20.18	36.50	35.56	
	21	4 a. m.	61° 19'	11° 14'	7.5	20.18	36.50	35.56	
		8 —	61° 20'	12° 6'	8.0	20.11	36.38	35.44	
		12 noon.	61° 51'	12° 58'	8.0	20.27	36.67	35.71	
		4 p. m.	62° 1'	13° 50'	7.7	20.11	36.38	35.44	
		8 —	62° 9'	14° 50'	8.0	20.15	36.45	35.51	
		12 night.	62° 19'	15° 42'	7.5	20.08	36.32	35.39	
	22	4 a. m.	62° 27'	16° 38'	7.5	20.04	36.25	35.32	
		8 —	62° 42'	17° 30'	7.5	20.18	36.50	35.56	
		12 noon	62° 57'	18° 22'	7.2	20.08	36.32	35.39	
		4 p. m.	63° 5'	19° 14'	7.2	20.15	36.45	35.51	
		8 —	63° 14'	19° 50'	7.0	20.04	36.25	35.32	
		12 night.	63° 24'	21° 6'	5.5	19.97	36.13	35.20	
	23	4 a. m.	63° 33'	22° 4'	5.0	19.97	36.13	35.20	
		8 —	63° 48'	22° 55'	4.7	19.97	36.13	35.20	
		12 noon.	64° 12'	23° 22'	2.5	19.75	35.78	34.83	
		4 —	64° 32'	23° 51'	3.0	19.90	36.00	35.08	
		8 —	65° 4'	24° 26'	0.5	19.58	35.42	34.53	

Station	May 1898		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	

4. Bergen—Arctic Ocean. H. M. S. Heimdal (Bie).

I	10		60° 50' N. 4° 29' E.	m.	° C.				
				0	6.3	18.71	33.84	33.02	
				10	6.5	18.75	33.91	33.09	
				20	6.0	19.11	34.55	33.70	
				40	6.0	19.48	35.21	34.33	
				60	6.0	19.60	35.42	34.53	
II	10		61° 5' N. 3° 39' E.	100	6.5	19.84	35.86	35.95	
				0	6.9	19.44	35.14	34.26	
				10	7.0	19.56	35.35	34.47	
				20	6.8	19.60	35.42	34.53	
				40	6.8	19.84	35.86	34.95	
				60	7.1	19.92	36.01	35.09	
III	10		61° 20' N. 2° 45' E.	80	7.2	20.04	36.21	35.28	
				120	7.3	20.04	36.21	35.28	
				200	7.5	20.08	36.28	35.35	
				0	7.4	19.68	35.58	34.68	
				10	7.4	19.73	35.66	34.75	
				20	7.4	19.73	35.66	34.75	
IV	10		61° 37' N. 1° 44' E.	40	7.5	20.00	36.14	35.21	
				60	7.6	20.08	36.28	35.35	
				80	7.3	20.08	36.28	35.35	
				120	7.2	20.08	36.28	35.35	
				0	8.0	20.00	36.14	35.21	
				10	8.0	20.04	36.21	35.28	
V	11		61° 53' N. 1° 2' E.	20	7.6	20.08	36.28	35.35	
				40	7.7	20.08	36.28	35.35	
				60	7.8	20.08	36.28	35.35	
				80	7.9	20.04	36.21	35.28	
				120	8.0	20.04	36.21	35.28	
				200	8.1	20.04	36.21	35.28	
VI	11	6 a. m.	62° 31' N. 0° 38' W.	0	8.0	20.12	36.36	35.45	
				10	8.0	20.12	36.36	35.45	
				20	8.0	20.12	36.36	35.45	
				40	7.9	20.12	36.36	35.45	
				60	7.8	20.12	36.36	35.45	
				0	8.0	20.08	36.28	35.35	
	11	1 p. m.		0	8.3	20.08	36.28	35.35	
				10	8.4	20.08	36.28	35.35	
				20	8.4	20.08	36.28	35.35	
				40	8.3	20.08	36.28	35.35	
				60	7.7	20.08	36.28	35.35	
				80	7.8	20.08	36.28	35.35	
	11			120	7.5	20.08	36.28	35.35	
				200	7.5	20.08	36.38	35.35	
				0	7.2	20.00	36.14	35.21	

## XII

Station.	May 1898		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
VII	11		63° 3' N. 2° 15' W.	m.	° C.				
				0	7.2	20.04	36.21	35.28	
				10	7.0	20.04	36.21	35.28	
				20	7.0	20.04	36.21	35.28	
				100	7.1	20.04	36.21	35.28	
VIII	11	7 <sup>1</sup> / <sub>4</sub> p. m.	63° 41' N. 3° 48' W.	0	5.5	19.83	35.85	34.93	
				0	5.0	19.76	35.72	34.80	
				0	3.2	19.73	35.66	34.75	
IX	12	8 a. m.	64° 34' N. 4° 40' W.	0	3.1	19.73	35.66	34.75	
				0	3.0	19.76	35.72	34.80	
X	13	6 <sup>1</sup> / <sub>2</sub> a. m.	65° 32' N. 5° 0' W.	0	2.7	19.76	35.72	34.80	
				0	2.0	19.73	35.66	34.75	
XI	14	6 a. m.	66° 20' N. 6° 26' W.	0	2.5	19.76	35.72	34.80	
				0	1.0	19.76	35.72	34.80	
XII	14		67° 29' N. 8° 10' W.	0	0.5	19.66	35.54	34.64	
				10	0.5	19.66	35.54	34.64	
				20	0.2	19.66	35.54	34.64	
				40	0.1	19.73	35.66	34.75	
				60	0.1	19.73	35.66	34.75	
				80	0.0	19.66	35.54	34.64	
				120	0.0	19.66	35.54	34.64	
				200	0.4	19.70	35.61	34.69	
				300	0.5	19.70	35.61	34.69	
				0	0.1 —	19.66	35.54	34.64	
				0	0.8 —	19.70	35.61	34.69	
				0	1.0 —	19.66	35.54	34.64	
				0	0.5 —	19.52	35.29	34.40	
				0	0.5 —	19.66	35.54	34.64	
XIII	18		67° 30' N. 11° 26' W.	0	0.5 —	19.66	35.54	34.64	
				10	0.6	19.62	35.47	34.56	
				20	0.7	19.62	35.47	34.56	
				40	0.7	19.59	35.42	34.53	
				60	0.8 —	19.62	35.47	34.56	
				80	1.9 —	19.62	35.47	34.56	
				120	0.9 —	19.62	35.47	34.56	
				200	1.0 —	19.62	35.47	34.56	
				300	1.3 —	19.66	35.54	34.64	

## XIII

Station	May 1898		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	

## 5. Arctic Ocean—Aalesund. May 1898. H. M. S. Heimdal (Bie).

19	12 noon.	67° 26' N.	m.	° C	19.62	35.47	34.56	
		10° 47' W.	0	4.0 —				
20	12 noon	67° 29.6' N.	0	0.2 —	19.66	35.54	34.64	
		10° 8' W.			19.66	35.54	34.64	
					19.66	35.54	34.64	
					19.66	35.54	34.64	
					19.66	35.54	34.64	
					19.66	35.54	34.64	
					19.66	35.54	34.64	
					19.66	35.54	34.64	
					19.66	35.54	34.64	
					19.66	35.54	34.64	
					19.66	35.54	34.64	
					19.66	35.54	34.64	
					19.66	35.54	34.64	
					19.66	35.54	34.64	
21	12 night.		0	2.2	19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
					19.84	35.86	34.95	
22	12 noon.	64° 55.8' N.	0	5.0	19.77	35.72	34.81	
		2° 53' W.			19.73	35.66	34.75	
					19.84	35.86	34.95	
					19.70	35.61	34.69	
					19.70	35.61	34.69	
					19.77	35.72	34.81	
					19.88	35.93	35.01	
					19.88	35.93	35.01	
					19.88	35.93	35.01	
					19.88	35.93	35.01	
					19.88	35.93	35.01	
					19.88	35.93	35.01	
					19.88	35.93	35.01	
					19.88	35.93	35.01	
22	12 noon.	62° 54' N.	0	7.2	19.15	34.62	33.78	
		5° 11.5' E.			18.94	34.25	33.41	
					18.97	34.31	33.46	
					18.28	33.07	32.29	
					18.28	33.07	32.29	
					18.28	33.07	32.29	
					18.28	33.07	32.29	
					18.28	33.07	32.29	
					18.28	33.07	32.29	
					18.28	33.07	32.29	
					18.28	33.07	32.29	
					18.28	33.07	32.29	
					18.28	33.07	32.29	
					18.28	33.07	32.29	
					18.28	33.07	32.29	
22	8 —	Aalesund Harbour	0	9.8	18.28	33.07	32.29	
					18.28	33.07	32.29	

Station	1898		Latitude N.	Longitude E.	Temperature of the surface of the water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	

6. Tromsø—Arctic Ocean, April—May 1898. <sup>s</sup><sub>s</sub> Hvidfisken,  
Capt. Fr. Svendsen.

					° C.				
April									
25	4 a. m.	71° 15' 9" N.	16° 41' E.	5.5	19.83	35.87	34.96		
	12 noon.	71° 30'	16° 43'	5.8	19.97	36.13	35.20		
26	12 —	72° 19'	15° 35'	5.7	19.97	36.13	35.20		
27	—	72° 39'	11° 24'	5.1	20.04	36.25	35.32		
28	—	73° 18'	9° 31'	4.0	20.04	36.25	35.32		
29	—	73° 39'	9° 1'	1.2	19.83	35.87	34.96		
	2 p. m.	73° 41'	9° 0'	0.2	19.76	35.75	34.84		
30	12 noon.	73° 35'	11° 36'	1.7	19.90	36.00	35.08		
May									
1	8 a. m.	74° 10'	10° 20'	2.5	19.83	35.87	34.96		
	12 noon.	74° 12'	10° 45'	3.4	19.97	36.13	35.20		
2	—	73° 23'	9° 45'	3.2	19.90	36.00	35.08		
3	—	72° 26'	8° 15'	3.5	19.97	36.13	35.20		
4	—	71° 43'	6° 7'	4.7	19.97	36.13	35.20		
5	—	71° 50'	4° 43'	5.0	20.04	36.25	35.32		
6	—	71° 50'	4° 35'	5.0	20.04	36.25	35.32		
7	4 a. m.	71° 42'	3° 24'	4.2	19.94	36.07	35.15		
	12 noon.	71° 40'	3° 52'	5.1	19.97	36.13	35.20		
8	—	71° 56'	4° 18'	5.1	20.04	36.25	35.32		
9	—	71° 27'	4° 40'	5.2	19.97	36.13	35.20		
10	—	71° 54'	3° 10'	4.0	19.97	36.13	35.20		
	6 p. m.	72° 8'	2° 20'	3.2	19.97	36.13	35.20		
11	12 noon.	71° 40'	3° 37'	4.0	19.97	36.13	35.20		
12	—	70° 56'	4° 18'	5.5	19.94	36.07	35.15		
13	—	70° 31'	4° 30'	5.5	20.04	36.25	35.32		
14	—	70° 19'	5° 35'	5.5	20.04	36.25	35.32		
15	—	71° 9'	5° 59'	4.5	20.04	36.25	35.32		
16	—	71° 55'	5° 33'	4.3	19.94	36.07	35.15		
17	—	71° 56'	2° 39'	3.4	19.94	36.07	35.15		
18	7 a. m.	72° 25'	4° 14'	0.2	19.76	35.75	34.84		
	12 noon.	72° 8'	4° 8'	3.9					
19	—	71° 53'	4° 31'	4.2	19.94	36.07	35.15		
20	—	72° 54'	7° 17'	2.7	19.83	35.87	34.96		
	6 p. m.	73° 10'	8° 46'	2.5	19.90	36.00	35.08		
21	—	73° 23'	9° 16'	4.5	19.97	36.13	35.20		
22	—	73° 0'	9° 7'	2.6	19.90	36.00	35.08		
23	—	73° 25'	9° 9'	4.6	19.97	36.13	35.20		
24	—	73° 45'	9° 46'	4.1	20.01	36.20	35.27		
25	—	73° 35'	9° 6'	4.4					
26	—	73° 28'	9° 52'	4.6	20.08	36.32	35.39		
27	—	74° 1'	11° 24'	4.9	20.04	36.25	35.32		
28	—	73° 31'	10° 23'	5.1	19.90	36.00	35.08		
29	—	72° 55'	7° 35'	6.4	19.97	36.13	35.20		
30	—	73° 3'	7° 51'	2.9	19.76	35.75	34.84		
31	—	72° 41'	8° 4'	5.4	19.94	36.07	35.15		
June									
1	—	72° 37'	8° 1'	2.1	19.90	36.00	35.08		
2	—	73° 11'	7° 43'	3.3	19.94	36.07	35.15		
3	—	72° 48'	7° 13'	5.6	19.94	36.07	35.15		
4	—	72° 56'	7° 5'	5.8	20.01	36.20	35.27		

Station	1898		Latitude N.	Longitude E.	Temperature of the surface water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litro	Salt per mille	
	June				° C.				
	5	12 non.	73° 9' N.	8° 28' E.	5.9	20.01	36.20	35.27	
	6	—	73° 39'	8° 48'	5.1	20.01	36.20	35.27	
	7	—	74° 16'	9° 49'	4.8	19.94	36.07	35.15	
	8	—	74° 36'	12° 1'	3.8	19.94	36.07	35.15	
	9	—	75° 3'	12° 25'	3.9	19.94	36.07	35.15	
	10	—	75° 13'	11° 4'	3.6	19.94	36.07	35.15	
	11	—	75° 41'	12° 0'	2.9	20.01	36.20	35.27	
	12	—	75° 43'	11° 48'	3.4	19.97	36.13	35.20	
	13	—	75° 36'	11° 4'	4.2	19.97	36.13	35.20	
	14	—	76° 40'	9° 57'	2.8	19.83	35.87	34.96	
	15	—	77° 0'	10° 38'	3.4	19.94	36.07	35.15	
	16	—	77° 7'	11° 17'	4.5	19.97	36.13	35.20	
	17	—	76° 27'.0	7° 36'	3.2	19.97	36.13	35.20	
	18	—	76° 46'	7° 53'	3.8	20.01	36.20	35.27	
	19	—	77° 4'	8° 53'	3.7	19.97	36.13	35.20	
	20	—	77° 3'	10° 52'	4.1	19.90	36.00	35.08	
	21	—	77° 1'	14° 5'	2.4	19.47	35.22	34.35	
	22	4 a. m.	77° 26'	18° 20'	1.8	19.33	34.97	34.11	
	22	12 noon.	77° 34'	15° 13'	3.6	18.23	32.99	32.22	

7. Tromsø—Arctic Ocean, April—June 1898. <sup>s</sup>/<sub>s</sub> Jasai.

Capt. J. Svendsen.

April					° C.				
24	8 a. m.	70° 8' N.	18° 1' E.	5.7	19.86	35.93	35.01		
24	12 noon.	71° 1'	16° 53'	5.3	19.68	35.60	34.71		
25	8 a. m.	71° 52'	16° 9'	5.9	19.94	36.07	35.15		
25	12 —	72° 30'	15° 42'	5.3	19.90	36.00	35.08		
26	12 —	72° 37'	14° 48'	5.7	19.97	36.13	35.20		
27	8 a. m.	72° 45'	11° 59'	4.7	20.01	36.20	35.27		
28	12 noon.	73° 6'	10° 26'	4.6	20.01	36.20	35.27		
29	—	73° 21'	9° 18'	3.4	19.97	36.13	35.20		
30	—	73° 36'	9° 17'	1.2	19.86	35.93	35.01		
May									
1	—	73° 41'	8° 59'	2.3	19.86	35.93	35.01		
2	—	73° 18'	7° 38'	3.7	19.86	35.93	35.01		
4	—	73° 7'	7° 16'	2.9	19.86	35.93	35.01		
5	—	72° 23'	6° 50'	3.2	19.94	36.07	35.15		
6	—	72° 5'	5° 42'	5.0	19.94	36.07	35.15		
7	—	71° 45'	4° 24'	4.9	19.94	36.07	35.15		
10	—	70° 55'	5° 23'	5.2	20.05	36.27	35.34		
13	—	70° 0'	5° 14'	5.0	20.08	36.32	35.39		
18	—	72° 28'	4° 50'	3.8	19.86	35.93	35.01		
19	—	72° 39'	7° 50'	0.6	19.86	35.93	35.01		
28	—	74° 12'	9° 49'	4.8	19.94	36.07	35.15		
28	8 p. m.	74° 0'	9° 50'	4.9	20.08	36.32	35.39		
29	12 noon.	74° 5'	9° 50'	4.7	20.08	36.32	35.39		
29	8 p. m.	74° 12'	9° 34'	4.9	20.01	36.20	35.27		
30	12 noon.	74° 2'	9° 19'	5.0	20.08	36.32	35.39		
31	—	73° 36'	8° 25'	4.0	19.97	36.13	35.20		
June									
1	—	78° 8'	8° 10'	1.7	19.68	35.60	34.71		
2	—	73° 8'	8° 40'	1.6	19.75	35.73	34.83		

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Station	1898		Latitude N.	Longitude E	Temperature the of surface water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
	June				° C.				
	2	8 p. m.	73° 1' N.	6° 8' E.	2.5	19.75	35.73	34.83	
	2	12 night.	73° 18'	6° 2'	1.8	19.90	36.00	35.08	
	3	12 noon.	73° 24'	6° 13'	2.4	19.86	35.93	35.01	
	4	—	73° 20'	6° 48'	1.2	19.75	35.73	34.83	
	5	—	73° 19'	7° 43'	4.3	19.90	36.00	35.08	
	6	—	73° 16'	8° 19'	2.8	19.86	35.93	35.01	
	7	—	74° 6'	8° 36'	3.8	19.97	36.13	35.20	
	8	—	74° 43'	10° 46'	3.2	19.97	36.13	35.20	
	9	8 a. m.	75° 6'	10° 22'	4.0	20.01	36.20	35.27	
	9	12 noon.	75° 7'	9° 52'	4.4	20.01	36.20	35.27	
	10	—	75° 27'	9° 19'	3.1	19.97	36.13	35.20	
	11	—	75° 57'	11° 53'	0.6	19.68	35.60	34.71	
	11	8 p. m.	76° 14'	15° 38'	0.8	19.52	35.31	34.48	
	12	12 noon.	76° 16'	13° 18'	3.6	20.05	36.27	35.34	
	13	—	76° 5'	10° 24'	4.0	20.01	36.20	35.27	
	14	—	76° 52'	9° 13'	3.9	20.01	36.20	35.27	
	15	—	77° 31'	9° 50'	5.0	19.90	36.00	35.08	
	16	—	77° 40'	10° 35'	4.7	19.26	34.85	33.99	
	16	8 p. m.	78° 2'	11° 1'	2.3	19.26	34.85	33.99	
	16	12 night.	78° 9'	11° 53'	2.8	19.19	34.72	33.87	
	17	12 noon.	78° 9'	13° 41'	3.8	19.12	34.59	33.75	
	19	—	78° 7'	15° 2'	5.2	8.67			

### 8. Arctic Ocean, Summer 1898, <sup>s</sup> Hvidfisken. Capt. Fr. Svendsen.

	June				° C.				
	22	12 noon.	77° 34' N.	15° 13' E	3.6	18.23	32.98	32.20	
	23	8 p. m.	—	—	4.3	17.70	32.04	31.31	
	24	8 a. m.	—	—	5.0	16.50	29.88	29.25	
	25	8 p. m.	—	—	4.8	16.78	30.38	29.74	
	July								
	14	8 a. m.	—	—	4.9	13.08	23.65	23.25	
	16	8 p. m.	—	—	2.9	18.80	33.99	33.17	
	24	8 —	—	—	4.6	17.36	31.42	30.71	
	26	8 a. m.	—	—	6.5	13.43	24.37	23.95	
	Aug.								
	2	8 a. m.	—	—	6.6	7.79			
	11	12 noon.	—	—	5.6	14.27	25.89	25.41	
	21	8 a. m.	—	—	3.8	18.09	32.72	31.96	
	29	9 a. m.	77° 32' N.	14° 51'	3.4	18.59	33.63	32.82	
	Septbr.								
	3	10 a. m.	77° 10'	12° 39'	2.6	19.12	34.57	33.71	
	4	12 noon.	76° 42'	12° 39'	6.3	19.83	35.87	34.96	
		12 night.	75° 59'	12° 2'	6.0				
	5	8 a. m.	75° 2'	12° 5'	6.1	19.97	36.13	35.20	
		12 noon.	74° 45'	12° 2'	6.6	19.94	36.07	35.15	
	6	—	74° 9'	9° 32'	6.9	19.83	35.87	34.96	
	7	8 a. m.	72° 52'	11° 40'	7.9	19.87	35.95	35.03	
		12 noon.	72° 42'	12° 48'	7.6	19.90	36.00	35.08	
		4 p. m.	72° 30'	13° 10'	8.6	19.94	36.07	35.15	
		8 —	72° 13'	14° 2'	9.0	19.94	36.07	35.15	
	8	8 a. m.	71° 58'	14° 52'	9.0	19.97	36.13	35.20	
		12 noon.	71° 43'	14° 44'	9.0				

## XVII

Station	1898		Latitude N.	Longitude E.	Temperature of the surface water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	

9. Arctic Ocean—Tromsø, September 1898, <sup>s</sup><sub>s</sub> Hvidfisken,  
Cap. Fr. Svendsen.

Septbr.					°C.			
8	4 p. m.	71° 30' N.	14° 30' E.	9.0	19.90	36.00	35.08	
	8 —	71° 15'	14° 10'	9.0	19.87	35.95	35.08	
9	8 a. m.	70° 48'	13° 16'	9.3	19.90	36.00	35.08	
	12 noon.	70° 36'	13° 59'	9.0	19.97	36.13	35.20	
	8 p. m.	70° 28'	13° 20'	9.0	20.01	36.20	35.27	
10	8 a. m.	70° 12'	13° 58'	9.5	19.83	35.87	34.96	
	12 noon.	70° 7'	14° 28'	9.8	19.94	36.07	35.15	
	8 p. m.	69° 53'	15° 58'	9.5	19.97	36.13	35.20	
11	8 a. m.	69° 57'	16° 53'	9.9	19.47	35.22	34.35	
	12 noon	69° 45'	17° 15'	9.9	19.47	35.22	34.35	
12	8 a. m.	69° 34'	18° 54'.5	9.1	18.69	33.82	33.01	

10. Arctic Ocean, Summer 1898. <sup>s</sup><sub>s</sub> Jazai, Capt. J. Svendsen.

June					°C.			
26	12 noon.	77° 19' N.	13° 7' E.	2.1	19.40	35.10	34.22	
27	4 a. m.	76° 52'	13° 31'	4.2	19.76	35.75	34.84	
	8 —	76° 24'	14° 4'	5.2	19.97	36.13	35.20	
	12 noon.	75° 55'	14° 13'	4.0	20.01	36.20	35.27	
	8 p. m.	75° 23'	13° 51'	6.2	19.97	36.13	35.20	
28	12 noon.	74° 6'	17° 20'	5.4	19.83	35.87	34.96	
29	—	73° 56'	20° 46'	5.7	20.15	36.45	35.51	
30	8 a. m.	73° 34'	23° 23'	6.7	19.97	36.13	35.20	
31	12 noon.	73° 16'	24° 3'	6.9	19.97	36.13	35.20	
July								
2	—	72° 53'	23° 0'	8.4	20.15	36.45	35.51	
3	—	70° 53'	20° 42'	9.2	19.58	35.42	34.53	
14	—	69° 54'	17° 31'	9.4	19.47	35.22	34.35	
16	—	71° 55'	15° 33'	9.8	19.83	35.87	34.96	
17	—	73° 56'	14° 22'	7.0	19.90	36.00	35.05	
18	—	74° 4'	11° 13'	6.8	19.97	36.13	35.20	
20	8 p. m.	74° 35'	9° 1'	6.4	19.97	36.13	35.20	
21	—	76° 19'	9° 40'	5.8	19.94	36.07	35.15	
	7 p. m.	77° 36'	11° 41'	6.0	19.86	35.93	35.01	
22	8 a. m.	77° 56'	13° 30'	4.0	19.94	36.07	35.15	
23	12 noon.	78° 10'	14° 0'	4.7				
30	—	77° 41'	14° 12'	4.5	17.95	32.48	31.72	
Aug.								
8	8 p. m.	77° 46'	14° 51'	4.1	18.69	33.82	33.01	
12	8 p. m.	—, —	—, —	4.3	17.11	30.97	30.29	

11. Spitzbergen—Tromsø, September 1898, <sup>s</sup><sub>s</sub> Jazai,  
Capt. J. Svendsen.

Septbr.					°C.			
7	12 noon.	77° 36' N.	14° 20' E.	1.2	16.82	30.45	29.79	
	8 p. m.	77° 19'	13° 2'	1.9	18.84	34.09	33.27	
8	8 a. m.	76° 52'	13° 42'	1.9				
	8 p. m.	76° 42'	14° 36'	2.8	19.58	35.42	34.53	

# XVIII

Station	1898		Latitude N.	Longitude E.	Temperature of the surface water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
Septb.	9	4 a. m.	76° 29' N.	13° 31' E.	4.5	19.62	35.49	34.60	
		12 noon.	76° 28'	12° 0'	5.0	19.94	36.07	35.15	
		8 p. m.	76° 16'	11° 22'	4.5	19.97	36.13	35.20	
	10	4 a. m.	76° 2'	10° 33'	4.6	19.90	36.00	35.05	
		12 noon.	75° 55'	11° 5'	4.2	19.97	36.13	35.20	
		8 p. m.	75° 40'	11° 15'	4.1	19.90	36.00	35.05	
	11	8 a. m.	75° 29'	10° 54'	4.1	19.90	36.00	35.05	
		12 noon.	75° 22'	10° 42'	4.3	19.90	36.00	35.05	
		8 p. m.	74° 52'	9° 50'	4.7	19.97	36.13	35.20	
	12	4 a. m.	74° 33'	9° 37'	4.8	19.90	36.00	35.05	
		12 noon.	75° 3'	9° 33'	4.8	19.90	36.00	35.05	
		8 p. m.	74° 56'	11° 49'	4.9	19.86	35.98	35.01	
	13	12 noon.	74° 31'	13° 57'	5.1	19.90	36.00	35.05	
	14	—	74° 39'	14° 30'	5.4	19.94	36.07	35.15	
	15	4 a. m.	74° 0'	15° 40'	6.2	19.94	36.07	35.15	
		12 noon.	73° 19'	16° 52'	6.1	19.94	36.07	35.15	
		8 p. m.	72° 39'	16° 51'	6.8				
	16	8 p. m.	70° 31'	16° 25'	6.7	19.76	35.75	34.84	
	18	12 noon.	70° 46'	21° 15'	7.3	19.54	35.35	34.47	
	19	8 a. m.	70° 27'	21° 5'	7.2				
	20	8 p. m.	69° 58'	20° 8'	6.3	18.69	33.82	33.01	

## 12. Iceland—North Sea, July 1897, <sup>s</sup>/<sub>1</sub> Westye Egeberg, Capt Tuft.

1897	Date	Hour	Latitude N.	Longitude W.	° C.	Cl per litre	Salt per litre	Salt per mille
July	16	8 p.	66° 7' N.	13° 51' W.	6.7	19.62	35.47	34.56
		12 night.	65° 58'	13° 15'	5.5	19.72	35.65	34.76
17		3 a. m.	65° 52'	12° 52'	8.0	19.21	34.74	33.87
		6 —	65° 43'	12° 21'	6.0	19.55	35.32	34.45
		3 p. m.	65° 32'	11° 32'	6.7	19.72	35.65	34.76
		8 —	65° 17'	10° 52'	5.7	19.65	35.53	34.63
18		11 —	65° 5'	10° 25'	6.5	19.65	35.53	34.63
		2 a. m.	64° 56'	10° 0'	6.0	19.65	35.53	34.63
		5 —	64° 46'	9° 32'	6.3	19.65	35.53	34.63
		8 —	64° 38'	8° 54'	5.5	19.65	35.53	34.63
		11 <sup>1</sup> / <sub>2</sub> —	64° 37'	8° 17'	6.5	19.65	35.53	34.63
		4 p. m.	64° 23'	7° 57'	7.5	19.65	35.53	34.63
		9 —	64° 10'	7° 37'	7.7	19.65	35.53	34.63
19		12 night.	63° 59'	7° 14'	7.7	19.65	35.53	34.63
		4 a. m.	63° 47'	6° 53'	7.0	19.65	35.53	34.63
		12 noon.	63° 36'	6° 36'	8.5	19.62	35.47	34.56
		4 p. m.	63° 28'	6° 6'	11.0	19.79	35.78	34.86
		7 <sup>3</sup> / <sub>4</sub> —	63° 19'	5° 50'	9.7	19.75	35.71	34.80
20		11 —	63° 12'	5° 21'	9.5	19.89	35.96	35.04
		2 a. m.	63° 3'	4° 56'	8.0	19.72	35.65	34.76
		5 —	62° 53'	4° 30'	9.0	19.75	35.71	34.80
		8 —	62° 44'	4° 4'	8.7	19.89	35.96	35.04
		11 <sup>1</sup> / <sub>2</sub> —	62° 37'	3° 44'	10.0	20.06	36.25	35.31
		3 night.	62° 27'	3° 18'	9.3	19.75	35.71	34.80
		6 p. m.	62° 16'	2° 58'	10.7	20.03	36.19	35.26
		8 <sup>1</sup> / <sub>3</sub> —	62° 6'	2° 34'	10.7	20.03	36.19	35.26
	11	—	61° 54'	2° 8'	11.0	19.92	36.01	35.09

# XIX

Station	1897		Latitude N.	Longitude W.	Temperature of the surface water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
	July 21	2 a. m.	61° 43' N.	1° 54' W.	11.5	19.99	36.15	35.20	
		5 —	61° 32'	1° 30'	12.0	20.09	36.30	35.86	
		9 —	61° 20'	1° 7'	12.0	20.19	36.48	35.57	
		12 noon.	61° 18'	0° 44'	12.5	20.16	36.43	35.58	
		4 p. m.	60° 58'	0° 42'	12.5	20.23	36.56	35.59	
	22	11 —	60° 48'	0° 22'	12.0	20.16	36.43	35.52	
		3 a. m.	60° 35'	0° 4'	12.0	20.16	36.43	35.52	
		7 —	60° 22' N.	0° 10' E.	11.5	20.03	36.19	35.26	
		12 noon.	60° 11'	0° 28'	12.5	19.92	36.01	35.09	
		4 p. m.	60° 0'	0° 44'	12.5	19.72	35.65	34.76	
	23	7 —	59° 49'	1° 2'	12.5	19.65	35.53	34.63	
		9 1/2 —	59° 39'	1° 22'	12.5	19.62	35.47	34.56	
		12 night.	59° 28'	1° 42'	12.7	19.55	35.32	34.45	
		3 a. m.	59° 18'	2° 8'	12.7	19.48	35.21	34.33	
		6 —	59° 7'	2° 25'	13.0	19.25	34.81	33.94	
		10 —	58° 56'	2° 40'	14.0	18.80	33.99	33.17	
		1 1/2 p. m.	58° 45'	2° 56'	14.5	18.52	33.51	32.70	
		6 —	58° 35'	3° 15'	15.0	17.71	32.06	31.33	
		10 —	58° 21'	3° 45'	15.0	17.74	32.11	31.38	

## 13. Iceland—Norway, July 1898, <sup>s</sup>/<sub>s</sub> Westye Egeberg, Capt. L. Tufte.

1898					° C.				
July	16	12 night.	66° 20' N.	14° 22' W.	7.2	19.47	35.22	34.35	
	17	2 1/2 a. m.	66° 10'	13° 57'	6.7	19.47	35.22	34.35	
		6 1/4 —	66° 2'	13° 26'	6.3				
		9 1/4 —	65° 52'	12° 56'	6.0	19.40	35.10	34.22	
		12 noon.	65° 40'	12° 22'	5.8	19.40	35.10	34.22	
		3 p. m.	65° 33'	12° 0'	6.0	19.54	35.35	34.47	
	18	5 1/2 —	65° 25'	11° 31'	6.1	19.54	35.35	34.47	
		8 —	65° 17'	11° 0'	5.5	19.54	35.35	34.47	
		11 1/4 —	65° 8'	10° 32'	6.1	19.69	35.62	34.72	
		1 1/4 a. m.	64° 59'	10° 3'	6.5	19.76	35.75	34.84	
		4 1/4 —	64° 50'	9° 33'	6.5	19.72	35.67	34.77	
		8 —	64° 42'	9° 5'	5.2	19.69	35.62	34.72	
		11 1/2 —	64° 30'	8° 40'	6.2	19.72	35.67	34.77	
		3 1/2 p. m.	64° 19'	8° 10'	6.3	19.76	35.75	34.84	
	19	7 1/2 —	64° 8'	7° 46'	6.3	19.76	35.75	34.84	
		11 —	63° 57'	7° 25'	6.3	19.69	35.62	34.72	
		2 3/4 a. m.	63° 46'	7° 0'	6.6	19.69	35.62	34.72	
		7 —	63° 34'	6° 39'	7.2	19.72	35.67	34.77	
		11 —	63° 13'	6° 13'	8.5	19.94	36.07	35.15	
		2 1/2 p. m.	63° 0'	6° 8'	8.2	19.83	35.87	34.96	
		5 1/4 —	62° 47'	5° 57'	7.3	19.80	35.82	34.91	
		7 3/4 —	62° 33'	5° 42'	9.9	20.08	36.32	35.39	
	20	10 —	62° 20'	5° 26'	9.6	20.04	36.25	35.32	
		2 1/3 a. m.	62° 17'	5° 8'	9.4	20.01	36.20	35.27	
		6 a. m.	61° 55'	4° 54'	8.3	19.90	36.00	35.08	
		8 —	61° 44'	4° 46'	10.2	20.08	36.32	35.39	
		10 1/4 —	61° 31'	4° 26'	10.2	20.08	36.32	35.39	
		12 noon.	61° 17'	4° 6'	10.2	20.08	36.32	35.39	

Station	1898		Latitude N.	Longitude W.	Temperature of the surface water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
July 20	2	p. m.	61° 6' N.	3° 50' W.	10.6	20.08	36.32	35.39	
	4	—	60° 52'	3° 20'	11.0	20.11	36.38	35.44	
	6	—	60° 40'	2° 55'	10.8	20.11	36.38	35.44	
	8	—	60° 26'	2° 10'	10.8	20.11	36.38	35.44	
	10 1/4	—	60° 16'	1° 56'	9.9	20.08	36.32	35.39	
	12	night	60° 5'	1° 46'	10.0	20.08	36.32	35.39	
	21	2 1/2 a. m.	59° 53'	1° 30'	9.3				
	8	—	59° 46'	1° 12'	10.8	20.08	36.32	35.39	
	10 1/4	—	59° 38'	0° 52'	11.0	20.01	36.20	35.27	
	0 1/2	p. m.	59° 29'	0° 26'	11.0	20.01	36.20	35.27	
	3 3/4	—	59° 20'	0° 3' W.	11.2	19.97	36.13	35.20	
	8	—	59° 10'	0° 21' E.	11.6	19.90	36.00	35.08	
22	12	night.	59° 3'	0° 46'	11.6	19.76	35.75	34.84	
	5 1/4	a. m.	58° 56'	1° 12'	12.0	19.62	35.49	34.60	
	8	—	58° 49'	1° 42'	12.1	18.69	33.82	33.01	
	12	noon.	58° 41'	2° 14'	12.5	18.06	32.67	31.93	

#### 14. Iceland—Leith, September 1898, <sup>s</sup>/<sub>s</sub> Heimdal,

Capt. H. C. Hansen.

Septb.					° C.				
14	8	p. m.	63° 47' N.	22° 52' W.	9.0	19.65	35.55	34.65	
	12	night.	63° 30'	22° 17'	9.0	19.65	35.55	34.65	
15	4	a. m.	63° 16'	21° 30'	9.0	19.94	36.07	35.15	
	8	—	63° 8'	20° 52'	9.5	19.97	36.13	35.20	
	12	noon.	62° 57'	20° 18'	9.5	19.97	36.13	35.20	
	4	p. m.	62° 49'	19° 48'	10.0	20.01	36.20	35.27	
	8	—	62° 40'	18° 48'	10.0	19.83	35.87	34.96	
	12	night	62° 31'	18° 0'	10.0	19.90	36.00	35.05	
16	4	a. m.	62° 23'	17° 6'	10.0	20.01	36.20	35.27	
	8	—	62° 18'	16° 15'	10.7	20.01	36.20	35.27	
	12	noon.	62° 0'	15° 33'	11.0	20.01	36.20	35.27	
	4	p. m.	61° 49'	14° 55'	10.5	20.04	36.25	35.32	
	8	—	61° 38'	14° 0'	10.0	20.04	36.25	35.32	
	12	night.	61° 30'	13° 8'	10.3	20.01	36.20	35.27	
17	4	a. m.	61° 21'	12° 26'	11.3	19.97	36.13	35.20	
	8	—	61° 12'	11° 26'	11.0	20.01	36.20	35.27	
	12	noon.	61° 6'	10° 42'	11.3	20.01	36.20	35.27	
	4	p. m.	60° 58'	9° 52'	11.0	20.01	36.20	35.27	
	8	—	60° 52'	8° 10'	10.5	20.01	36.20	35.27	
	12	night.	60° 46'	8° 16'	10.5	20.01	36.20	35.27	
18	4	a. m.	60° 40'	7° 28'	10.5	20.04	36.25	35.32	
	8	—	60° 37'	6° 46'	10.3	19.97	36.13	35.20	
	12	noon.	60° 33'	6° 15'	9.4	20.04	36.25	35.32	
	4	p. m.	60° 18'	5° 24'	10.5	20.04	36.25	35.32	
	8	—	60° 5'	4° 35'	11.3	20.04	36.25	35.32	
	12	night.	59° 50'	3° 44'	12.0	20.04	36.25	35.32	
19	4	a. m.	59° 38'	2° 58'	11.7	20.01	36.20	35.27	
	8	—	59° 32'	2° 38'	12.3	19.97	36.13	35.20	
	12	noon.	59° 9'	2° 12'	12.3	19.94	36.07	35.15	

## XXI

Station	1898		Latitude N.	Longitude W.	Temperature of the surface water	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
Septb.	19	4 p. m.	58° 43' E.	2° 5' W.	12.0	19.90	36.00	35.05	
		8 —	58° 18'	1° 59'	12.0	19.94	36.07	35.15	
		12 night.	57° 54'	1° 50'	12.0	19.87	35.95	35.03	
	20	4 a. m.	57° 28'	1° 29'	12.5	19.83	35.87	34.96	
		8 —	56° 57'	1° 43'	12.6	19.83	35.87	34.96	
		12 noon.	56° 40'	2° 0'	12.6	19.80	35.82	34.91	
					° C.				



## **II. Observations at the coast of Nordland 1898.**



## A. Observations in the West-Fiord.

Station	1898		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	

## a. Square and Length-Section of the Fiord 15—27th July 1898.

I.	July 16	12 noon.	67° 21' N. 13° 58' E.	m.	° C.				Ekman's Water-fet-cher and M. Knudsens Ther-mometer.
				0	12.0	19.12	34.57	33.71	
				5	12.1	19.23	34.76	33.89	
				10	11.9	19.23	34.76	33.89	
				20	11.6	19.23	34.76	33.89	
				30	8.5	19.30	34.89	34.03	
				40	7.2	19.44	35.14	34.26	
				50	6.6	19.47	35.19	34.32	
				80	6.0	19.54	35.32	34.42	
				100	5.9	19.54	35.32	34.42	
				120	5.8	19.62	35.47	34.56	
				200	6.0	19.79	35.78	34.86	
II.	16	4 p. m.	67° 24' N. 13° 28' E.	0	13.8	19.26	34.81	33.95	— — —
				12	11.04	19.19	34.69	33.84	
				20	10.1	19.26	34.81	33.95	
				30	7.3	19.44	35.14	34.26	
				50	6.0	19.47	35.19	34.32	
				80	5.8	19.58	35.40	34.51	
				100	6.0	19.58	35.40	34.51	
				200	6.1				
III.	16	8 p. m.	67° 25' N. 12° 53' E.	0	13.5	19.30	34.89	34.03	— — —
				10	11.6	19.26	34.81	33.95	
				20	9.65	19.44	35.14	34.26	
				30	8.0	19.47	35.19	34.32	
				50	6.7	19.65	35.53	34.63	
				80	6.5	19.65	35.53	34.63	
				120	6.6	19.76	35.72	34.80	
				200	6.1				
IV.	17	10 a. m.	67° 42' N. 13° 13.7' E.	0	12.18	19.23	34.76	33.89	— — —
				10	11.35	19.23	34.76	33.89	
				20	10.3	19.19	34.69	33.84	
				30	7.1	19.30	34.89	34.03	
				50	5.4	19.37	35.01	34.14	
				80	4.9				
				100	4.9	19.47	35.19	34.32	
				150	5.9	19.62	35.47	34.56	
				200	6.1	19.83	35.85	34.93	
V.	17	3 p. m.	67° 54.6' N. 13° 57' E.	0	11.9	19.19	34.69	33.84	— — —
				10	10.3	19.26	34.81	33.95	
				20	9.1	19.30	34.89	34.03	
				30	6.2	19.33	34.94	34.07	
				50	5.3	19.40	35.06	34.20	
				80		19.47	35.19	34.32	
				100		19.62	35.47	34.56	
				150	6.0	19.76	35.72	34.80	
				200	6.1	19.83	35.85	34.93	

## XXVI

Station	1898		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
VI.	July 26	2 <sup>3</sup> / <sub>4</sub> a. m.	68° 6' N. 14° 59' E.	m.	° C.				O. Pettersson's Water-fetcher.
				0	12.7				
				10	12.8	19.01	34.38	33.54	
				20	9.5	19.12	34.57	33.71	
				30	6.2	19.23	34.76	33.89	
				40	6.35	19.33	34.94	34.07	
				50	5.2	10.37	35.01	34.14	
				70	5.7				
				100	6.25	19.72	35.65	34.76	
				150	6.1	19.72	35.65	34.76	
				200	6.5	19.97	36.08	35.16	
O <sub>2</sub>	27	2 p. m.	68° 21' N. 16° 1' E.	0	12.9	15.69	28.43	27.86	— —
				5	13.0	15.61	28.29	27.72	
				10	11.82	18.52	33.51	32.70	
				20	10.07	18.98	34.32	33.48	
				30	7.57	19.08	34.51	33.65	
				50	5.35	19.37	35.01	34.14	
				70	5.46	19.54	35.32	34.42	
				100	5.23	19.46	35.16	34.30	
				150	5.65	19.56	35.35	34.47	

## b. Square section of the West-Fiord, 3rd August.

V <sub>1</sub>	Aug. 3	12 night.	67° 35' N. 13° 14' E.	m.	° C.				— —
				0	12.45	19.12	34.57	33.71	
				10	12.4	19.12	34.57	33.71	
				15	12.4	19.16	34.65	33.79	
				30	8.05	19.47	35.19	34.32	
				40	7.08	19.40	35.06	34.20	
				50	7.3	19.40	35.06	34.20	
				70	6.6				
V <sub>2</sub>	3	4 a. m.	67° 31' 5" N. 13° 46' 7" E.	0	12.13	19.19	34.69	33.84	— —
				10		19.23	34.76	33.89	
				20	8.7	19.33	34.94	34.07	
				30	7.3	19.40	35.06	34.20	
				40	6.85	19.44	35.14	34.26	
				60	6.18	19.54	35.32	34.42	
				80	6.25				
				100	6.3	19.65	35.53	34.63	

## c. Square section of the Fiord 8th September.

V <sub>1</sub>	Sept. 8	7 <sup>1</sup> / <sub>2</sub> a. m.	67° 35' N. 13° 14' E.	m.	° C.				— —
				0	10.45	18.98	34.32	33.48	
				10	10.5	18.98	34.32	33.48	
				20	10.47	18.98	34.32	33.48	
				30	10.33	19.19	34.69	33.84	
				40	8.37	19.30	34.89	34.03	
				60	7.25	19.44	35.14	34.26	
				80	6.35	19.58	35.40	34.51	
				100	6.3	19.65	35.53	34.63	

## XXVII

Station	1898		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
V <sub>1</sub>	Septb. 8	7 $\frac{1}{2}$ a. m.	67° 35' N. 13° 14' E.	m.	° C.				
				150	6.4	19.83	35.85	34.93	
				200	6.5	19.97	36.08	35.16	
V <sub>2</sub>	8	5 $\frac{1}{2}$ a. m.	67° 31' 5" N. 13° 46' 7" E.	0	10.6	18.98	34.32	33.48	
				10	10.7	18.98	34.32	33.48	
				20	10.7	19.19	34.69	33.84	
				30	10.6	19.44	35.14	34.26	
				40	10.48	19.47	35.19	34.32	
				50	10.4	19.47	35.19	34.32	
				70	8.43	19.44	35.14	34.26	
				100	6.25	19.54	35.32	34.42	
				150	6.25	19.90	35.98	35.05	
				200	6.5	19.98	36.43	35.11	

## d. Ofoten and Tys-Fiord.

T <sub>2</sub>	July 26	4 p. m.	68° 15' 4" N. 16° 7' 3" E. Korsnes in Tys-Fiord.	m.	° C.				
				0	13.6	17.36	31.42	30.71	
				10	11.5	18.78	33.87	33.05	
				20	9.18	18.98	34.32	33.48	
				30	7.08	19.05	34.44	33.62	
				40	6.05	19.19	34.69	33.84	
				50	5.5	19.23	34.76	33.89	
				70	5.4	19.40	35.06	34.20	
				100	5.4				
O <sub>2</sub>	26	11 p. m.	68° 28' N. 16° 58' E. Liland in Ofoten.	0	13.4	13.63	24.73	24.30	
				10	11.0	18.23	32.98	32.20	
				20	8.55	18.69	33.80	32.99	
				30	6.55	18.94	34.25	33.41	
				50	5.1	19.23	34.76	33.89	
				70	5.3	19.44	35.14	34.26	
				90	5.45				
O <sub>1</sub>	Aug. 7		Off Narvik in Ofoten	0	13.53	14.11			
				10	11.72	16.70	30.23	29.58	
				20	10.04	18.41	33.31	32.53	
				30	8.0	18.62	33.69	32.89	
				40	5.98	18.87	34.14	33.32	
				50	5.27	19.16	34.67	33.81	
				60	5.1	19.19	34.72	33.87	
				70	5.14	19.30	34.92	34.05	
O <sub>2</sub>	9		68° 28' N. 16° 58' E. Liland in Ofoten.	0	12.93	15.86	28.72	28.14	
				10	11.95	17.85	32.31	31.57	
				20	10.65	18.34	33.19	32.41	
				30	10.15	18.48	33.44	32.65	
				40	8.4	18.80	34.02	33.20	
				50	6.75	18.98	34.34	33.51	
				60	5.6	19.09	34.54	33.69	
				80	5.38	19.33	34.97	34.11	

## XXVIII

Station	1898		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
T <sub>1</sub>	Aug. 12		Kjølsvik in Tys-Fjord.	m.	° C.				Ekman's, Water-fetehor and M. Knudsen's Thermometer.
				0	12.9	15.64	28.32	27.76	
				10	13.88	18.16	32.86	32.10	
				20		18.59	33.64	32.84	
				30	12.3	18.73	33.89	33.08	
				40	10.5	18.73	33.89	33.08	
				50	8.0	18.84	34.09	33.27	
				60	6.22				
				70	5.7	18.90	34.20	33.37	
				80	5.5				
				90	5.8	19.23	34.79	33.93	
				120	6.0				
T <sub>2</sub>	13		68° 25' 4 N. 16° 7' 3 E. Korsnes in Tys-Fjord.						—, —
				0	14.28	16.92	30.63	29.96	
				10	13.65	18.59	33.64	32.84	
				20	13.58	18.66	33.76	32.96	
				30	11.18	18.84	34.09	33.27	
				40	9.7	18.91	34.22	33.39	
				50	7.3	19.05	34.47	33.63	
				60	6.4				
				70	6.3	19.26	34.85	33.99	
				100	6.0	19.33	34.97	34.11	
O <sub>1</sub>	Septb. 25		Narvik in Ofoten.	0	10.2	16.15	29.24	28.64	Pettersson's Water-fetehor.
				10	11.48	17.17	31.08	30.40	
				20	11.3	18.27	33.05	32.29	
				30	10.73	18.55	33.57	32.77	
				40	10.32	18.66	33.76	32.96	
				60	7.8	18.87	34.14	33.32	
O <sub>2</sub>	25		68° 28' N. 16° 58' E. Liland in Ofoten.	0	10.1	16.17	29.28	28.67	
				20	11.3	18.20	32.94	32.17	
				40	10.68	18.73	33.89	33.08	

## e. Near Bodø.

	July 23	10 a. m.	Bodø	m.	° C.				—, —
				0	11.63	18.66	33.75	32.94	
				10	11.5	18.73	33.87	33.05	
				20	9.88	18.91	34.19	33.36	
				30	9.2	18.94	34.25	33.41	
				40	8.25	19.12	34.57	33.71	
				50	7.32	19.33	34.94	34.07	
				60	6.85	19.40	35.06	34.20	
				100	6.7	19.54	35.32	34.42	
	Aug. 16		Bodø	0	13.32	18.52	33.51	32.70	—, —
				10	13.29	18.52	33.51	32.70	
				20	13.33	18.55	33.56	32.76	
				30	13.13	18.55	33.56	32.76	
				40	11.6	18.77	33.94	33.12	
				50	9.24	19.08	34.51	33.65	
				70	7.78	19.40	35.06	34.20	
				100	7.25	19.54	35.32	34.42	

## XXIX

Station	1898		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
	Aug. 23		Bode	m.	°C.				Pettersson's Water-fetcher.
				0	13.22	18.31	33.12	32.24	
				10	12.7	18.34	33.18	32.40	
				20	12.6	18.38	33.25	32.47	
				30	12.5	18.41	33.31	32.52	
				40	10.5	18.80	33.99	33.17	
				50	9.67	19.44	35.14	34.26	
	Sept. 7		—, —	60	9.0	19.44	35.14	34.26	
				70	7.93	19.44	35.14	34.26	
				0	10.5				
				10	10.55	18.41	33.31	32.54	
				20	10.58	18.59	33.64	32.84	
				30	10.57	18.69	33.82	33.01	
				40	10.63	18.73	33.89	33.05	
				50	10.76	19.08	34.52	33.65	
				60	10.23	19.23	34.79	33.93	
				10	9.93	18.59	33.64	32.84	
				20	10.4	19.12	34.59	33.75	
				30	10.33	19.23	34.79	33.93	
				40	10.22	19.30	34.92	34.05	
				60	10.24	19.30	34.92	34.05	
	Octbr. 18		—, —	0	8.3	18.55	33.57	32.77	
				10	8.64	18.55	33.57	32.77	
				20	8.60	18.55	33.57	32.77	
				30	8.65	18.55	33.57	32.77	
				50	9.8	18.75	33.89	33.08	

## B. Eids-Fiord

Station	1898		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	

## a. Section of the Eids-Fiord 29—30th July.

E <sub>1</sub>	July 29		68° 36' N. 14° 40' E.	m.	° C.				
				0	12.8	19.08	34.52	33.68	
				10	12.16	19.23	34.79	33.93	
				20	9.17	19.37	35.04	34.17	
				30	7.62	19.47	35.22	34.35	
				50	6.66	19.54	35.35	34.47	
				70	6.35	19.54	35.35	34.47	
				100	5.4	19.54	35.35	34.47	
				150	6.8	19.54	35.35	34.47	
				200	6.3	19.62	35.49	34.60	
E <sub>2</sub>	30	11½ a. m.	68° 40' N. 14° 53.5' E.	0	12.65	19.12	34.59	33.75	
				10	10.69	19.26	34.85	33.99	
				20	9.4	19.33	34.97	34.11	
				30	7.25	19.33	34.97	34.11	
				50	5.92	19.44	35.17	34.29	
				70	5.69	19.44	35.17	34.29	
				100	5.25				
E <sub>1</sub>	30	1½ p. m.	68° 43' N. 15° 6' E.	0	12.45	19.05	34.47	33.63	
				10	12.0	19.12	34.59	33.75	
				20	9.4	19.30	34.92	34.05	
				30	6.75	19.30	34.92	34.05	
				50	5.6	19.37	35.04	34.17	
				70	5.1	19.40	35.10	34.23	
				100	4.88	19.44	35.17	34.29	

## b. Section off the Fiord 22—23rd September.

E <sub>2</sub>	Sept. 22	2 p. m.	68° 52' N. 13° 12.5' E.	m.	° C.				
				0	9.77	19.79	35.80	34.89	
				10	9.77	19.83	35.87	34.96	
				20	9.78	19.86	35.93	35.01	
				30	9.82	19.97	36.13	35.20	
				40	9.75	19.97	36.13	35.20	
				50	9.2	19.97	36.13	35.20	
				60	8.72	19.97	36.13	35.20	
				70	7.78	20.08	36.32	35.39	
				80	7.35	20.08	36.32	35.39	
				100	7.05	20.08	36.32	35.39	
				150	7.08	20.11	36.38	35.44	
				200	7.05	20.15	36.45	35.51	
				300	6.97	20.15	36.45	35.51	
E <sub>2</sub>	22	5 p. m.	68° 43' N. 13° 41' E.	0	9.82	19.69	35.62	34.72	
				10	9.82	19.72	35.67	34.77	
				20	9.86	19.76	35.75	34.84	
				30	9.80	19.76	35.75	34.84	
				40	9.63	19.79	35.80	34.89	

## XXXI

Station	1898		Locality	Depth from which the sample obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
E5	Septb 22	5 p. m.	68° 48' N. 13° 41' E.	m.	° C.				
				60	8.18	19.88	35.87	34.96	
				80	7.35	19.90	36.00	35.08	
				100	6.95	20.08	36.52	35.39	
E4	22	8 p. m.	68° 35' N. 14° 8' E.	0	9.7	18.87	34.14	33.32	
				20	9.85	19.33	34.97	34.11	
				40	9.9	19.54	35.35	34.47	
				50	9.9	19.58	35.42	34.53	
				80	9.9	19.76	35.75	34.84	
				100	9.9	19.79	35.80	34.89	
				150	7.7	19.86	35.93	35.01	
				200	6.95	20.01	36.20	35.27	
E5	23	7½ a. m.	68° 36' N. 14° 40' E.	0	9.92	18.69	33.82	33.01	
				10	10.05	19.05	34.47	33.63	
				20	9.93	19.16	34.67	33.81	
				30	10.05	19.38	34.97	34.11	
				40	10.07	19.33	34.97	34.11	
				50	9.92	19.44	35.17	34.29	
				60	9.72	19.47	35.22	34.35	
				80	9.05	19.51	35.30	34.41	
				100	8.56	19.51	35.30	34.41	
				150	6.88	19.83	35.87	34.96	
				200	6.25	18.83	35.87	34.96	
E2	23	9 a. m.	68° 40' N. 14° 53.5 E.	0	9.9				
				10	10.15	18.98	34.34	33.51	
				20	10.1	19.12	34.59	33.75	
				30	10.33	19.30	34.92	34.05	
				40	10.2	19.37	35.04	34.17	
				50	10.0	19.44	35.17	34.29	
				60	9.83	19.44	35.17	34.29	
				80	9.08	19.44	35.17	34.29	
				100	7.61	19.44	35.17	34.29	
				150	6.55	19.72	35.67	34.77	
				200	6.13	19.79	35.80	34.89	



### **III. Sections off the Eids-Fiord, Nordland 1899.**



## III. Sections off the Eids-Fiord, Nordland 1899.

Station	July 1899		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	

## a. Section off the Eids-Fiord 4—5th July.

E <sub>3</sub>	4	12 <sup>1</sup> / <sub>2</sub> p. m.	68° 52' N. 13° 12.5' E.	m	° C.				
				0	11.2	19.38	35.06	34.19	
				10	10.8	19.43	35.15	34.28	
				20	8.63	19.63	35.51	34.62	
				30	7.5	19.74	35.71	34.81	
				40	7.2	19.86	35.93	35.01	
				50	6.8	19.95	36.09	35.17	
				70	6.25	19.95	36.09	35.17	
				100	6.56	20.06	36.29	35.36	
				120	6.2	20.08	36.32	35.39	
				150	6.1	20.02	36.22	35.29	
				200	6.2	20.13	36.41	35.47	
E <sub>5</sub>	4	3 p. m.	68° 43' N. 13° 41' E.	0	11.92	19.28	34.88	34.02	
				10	9.2	19.37	35.04	34.17	
				20	7.38	19.39	35.08	34.21	
				35	6.25	19.51	35.30	34.41	
				50	6.0	19.59	35.44	34.55	
				70	6.2	19.75	35.73	34.83	
				100	6.2	19.82	35.86	34.94	
E <sub>4</sub>	4	5 <sup>1</sup> / <sub>2</sub> p. m.	68° 35' N. 14° 8' E.	0	11.6	19.28	34.88	34.02	
				10	9.1	19.31	34.94	34.07	
				20	8.08	19.45	35.19	34.31	
				30	7.7	19.45	35.19	34.31	
				40	7.2	19.72	35.67	34.77	
				50	6.55	19.77	35.76	34.86	
				70	5.3	19.68	35.60	34.71	
				100	5.2	19.70	35.64	34.74	
				150	6.0	19.88	35.96	35.05	
				200	6.0	19.88	35.96	35.05	
E <sub>3</sub>	5	10 a. m.	68° 36' N. 14° 40' E.	0	12.9	18.84	34.09	33.37	
				10	10.0	19.07	34.50	33.66	
				15	7.0	19.31	34.94	34.07	
				20	6.5	19.42	35.13	34.26	
				30	6.15	19.51	35.30	34.41	
				50	5.6	19.54	35.35	34.47	
				70	5.5	19.54	35.35	34.47	
				100	4.7	19.49	35.26	34.38	
				120	4.38	19.54	35.35	34.47	
				150	4.55	19.63	35.51	34.62	
				200	5.35	19.66	35.54	34.64	
E <sub>2</sub>	5	12 <sup>1</sup> / <sub>2</sub> a. m.	68° 40' N. 14° 53.5' E.	0	10.35	18.80	33.99	33.17	
				5	11.06	18.80	33.99	33.17	
				13	7.15	19.10	34.56	33.72	
				30	5.7	19.31	34.94	34.07	
				50	5.0	19.31	34.94	34.07	
				75	4.3	19.31	34.94	34.07	

# XXXVI

Station	July 1899		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
E <sub>2</sub>	5	12 $\frac{1}{2}$ p. m.	68° 40' N. 14° 53'.5 E.	m.	° C.				
				100	4.45	19.38	35.06	34.19	
				150	4.0	19.38	35.06	34.19	
E <sub>1</sub>	5	3 $\frac{1}{2}$ p. m.	68° 43' N. 15° 6' E.	200	3.73	19.38	35.06	34.19	
				0	12.2	18.71	33.85	33.04	
				10	8.3	19.03	34.43	33.59	
				20	6.1	19.22	34.77	33.92	
				30	5.25	19.23	34.79	33.93	
				50	4.55	19.24	34.81	33.95	
				70	4.08	19.21	34.76	33.90	

## b. Eids-Fiord 19th July.

E <sub>3</sub>	July 19	11 a. m.	68° 36' N. 14° 40' E.	m.	° C.				
				0	14.6	19.04	34.45	33.61	
				10	10.4	19.29	34.90	34.04	
				20	8.15	19.44	35.17	34.29	
				30	7.2	19.47	35.22	34.35	
				40	6.6	19.47	35.22	34.35	
				60	5.95	19.47	35.22	34.35	
				70	5.15	19.42	35.13	34.26	
				100	5.0	19.47	35.22	34.35	
E <sub>2</sub>	19	6 p. m.	68° 40' N. 14° 53'.5 E.	0	15.15	18.60	33.66	32.85	
				10	9.25	19.13	34.61	33.76	
				20	7.7	19.25	34.83	33.97	
				30	7.15	19.33	34.97	34.11	
				50	6.0	19.47	35.22	34.35	
				70	5.0	19.50	35.28	34.40	
				80	4.7	19.47	35.22	34.35	
				100	3.9	19.47	35.22	34.35	

## c. Section off the Eids-Fiord 24—25th July.

E <sub>6</sub>	July 24		68° 52' N. 13° 12'.5 E.	m.	° C.				
				0	14.05	19.48	35.24	34.36	
				10	13.8	19.48	35.24	34.36	
				20	6.7	19.59	35.44	34.55	
				30	6.75	19.70	35.64	34.74	
E <sub>4</sub>	24	10 a. m.	68° 35' N. 14° 8' E.	0	13.88	19.37	35.04	34.17	
				10	13.8	19.37	35.04	34.17	
				20	12.35	19.37	35.04	34.17	
				25	9.0				
				40	6.3				
				50	5.8	19.47	35.22	34.35	
				70	5.1	19.54	35.35	34.47	
				100	5.9	19.70	35.64	34.74	
				150	6.25	19.72	35.65	34.76	
				200	6.25	19.86	35.93	35.01	

## XXXVII

Station	July 1899		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
E <sub>3</sub>	25	6 p. m.	68° 36' N. 14° 40' E.	m. 100 150 200	° C.   	19.44 19.70 19.75	35.17 35.64 35.73	34.29 34.74 34.83	
E <sub>2</sub>	25	10½ a. m.	68° 40' N. 14° 53.5 E.	0 10 20 30 40 50 70 100 145 160 200	14.65 10.5 9.1 8.0 7.08 6.15 5.35 4.4 4.8 5.05 5.35	18.83 19.08 19.17 19.30 19.34 19.34 19.41 19.30 19.55 19.64 19.64	34.07 34.52 34.68 34.92 34.99 34.99 35.12 34.92 35.37 35.53 35.53	33.25 33.68 33.83 34.05 34.12 34.12 34.24 34.05 34.48 34.64 34.64	
E <sub>1</sub>	25	1 p. m.	68° 43' N. 15° 6' E.	0 10 20 30 40 60 80 115	      4.55 4.0	18.55 18.98 18.98 19.26 19.26 19.30 19.37 19.41	33.57 34.34 34.34 34.85 34.85 34.92 35.04 35.12	32.77 33.51 33.51 33.99 33.99 34.05 34.17 34.24	

## d. Eids-Fiord 9th—14th August.

E <sub>2</sub>	Aug. 9	68° 40' N. 14° 53.5 E.	m. 0 10 20 30 40 50 80	° C. 11.4 11.3 11.2 11.2 6.55 5.15 4.8	18.70 18.96 19.11 19.22 19.22 19.40 19.45	33.84 34.31 34.58 34.77 34.77 35.10 35.19	33.03 33.47 33.73 33.92 33.92 34.23 34.31	
E <sub>3</sub>	12	68° 36' N. 14° 40' E.	0 10 20 30 40 70	10.75 10.65 10.65 10.75 10.55 6.75	18.89 19.05 19.16 19.22 19.31 19.35	34.18 34.47 34.67 34.77 34.94 35.01	33.35 33.63 33.81 33.92 34.07 34.14	
E <sub>2</sub>	12	68° 40' N. 14° 53.5 E.	0 10 20 30 40 50 70	10.9 10.95 10.85 10.7 8.4 8.0 6.2	18.24 19.04 19.12 19.22 19.28 19.28 19.36	33.01 34.45 34.59 34.77 34.88 34.88 35.03	32.24 33.61 33.75 33.92 34.02 34.02 34.16	
E <sub>3</sub>	14	68° 36' N. 14° 40' E.	0 10	10.6 10.4	18.96 19.07	34.31 34.50	33.47 33.66	

Station	August 1899		Locality	Depth from which sample was obtained	Temperature of the water at that depth	Saline contents			Remarks
	Date	Hour				Cl per litre	Salt per litre	Salt per mille	
E <sub>3</sub>	14			m.	° C.				
				20	10.4	19.15	34.65	33.80	
				30	9.75	19.34	34.99	34.12	
				40	9.6				
				50	9.1	19.40	35.10	34.23	
				70	8.2	19.47	35.22	34.35	

## e Section off the Eids-Fiord 26th—28th August.

E <sub>3</sub>	26	1 1/2 p. m.	68° 52' N. 18° 12' 5" E.	m.	° C.				
				0	9.15	19.74	35.71	34.81	
				10	9.0	19.84	35.89	34.98	
				20	8.9	19.84	35.89	34.98	
				30	8.65	19.84	35.89	34.98	
				50	8.0	19.91	36.02	35.10	
				70	7.9	19.98	36.14	35.22	
				100	7.2	19.98	36.14	35.22	
E <sub>4</sub>	26	9 a. m.	68° 35' N. 14° 8' E.	150	6.8	19.95	36.09	35.17	
				200	6.8	20.05	36.27	35.34	
				0	9.02	19.12	34.59	33.75	
				10	8.95	19.16	34.67	33.81	
				20	8.85	19.30	34.92	34.05	
				30	8.6	19.30	34.92	34.05	
				50	8.35	19.44	35.17	34.29	
				70	6.8	19.44	35.17	34.29	
E <sub>5</sub>	28	8 p. m.	68° 36' N. 14° 40' E.	100	6.5	19.58	35.42	34.53	
				150	6.2	19.72	35.67	34.77	
				0	10.1	18.98	34.34	33.51	
				50	8.1	19.30	34.92	34.05	
				70	7.1	19.34	34.99	34.12	
				100	5.3	19.44	35.17	34.29	
				150	5.9	19.62	35.49	34.60	
				200	5.8	19.80	35.82	34.91	
E <sub>6</sub>	26	5 1/2 p. m.	68° 40' N. 14° 53' 5" E.	0	10.22	18.90	34.20	33.37	
				10	9.7	19.08	34.52	33.68	
				20	9.5	19.16	34.67	33.81	
				30	8.95	19.16	34.67	33.81	
				50	8.35	19.30	34.92	34.05	
				70	6.7	19.34	34.99	34.12	
				100	5.1	19.48	35.24	34.36	
				150	5.4	19.59	35.44	34.55	
E <sub>7</sub>	28	1 p. m.	68° 43' N. 15° 6' E.	200	5.45	19.66	35.57	34.67	
				0	10.5	18.37	33.24	32.46	
				10	10.5	18.34	34.27	33.44	
				20	10.2	19.05	34.47	33.63	
				30	9.4	19.16	34.67	33.81	
				40	8.7	19.28	34.88	34.02	
				50	8.15	19.30	34.92	34.05	
				70	7.08	19.30	34.92	34.05	
				90	6.8	19.30	34.92	34.05	





# PLANKTON TABLES



## Remarks on the Plankton Tables.

All the Samples of Plankton were obtained by means of a net formed of the finest silk (no. 20), the greater part being taken in a quantitative vertical net, invented by Hensen, furnished with C. G. Joh. Petersen's closing mechanism. The total weight of these quantitative samples is given, and the total individual numbers of *Calanus finmarchicus* Guun.

The diameter of the mouth of the net is 38 cms., but in consequence of the closing mechanism, a plate 58 cm. in width lies across the centre. The superficial area of the opening is thus about 0.09 square metres.

The weighing of the preserved samples was carried out according to C. G. Joh Petersen's method. During this process, the organisms contained 70% of alcohol, whilst all other extraneous matter was removed so far as possible, by filtering paper. Those samples which were rich in diatoms or radiolarians could not, however be ridded of the excess of alcohol so well as the others.

On a systematic investigation of the samples, I have attached great weight to those species which prevail in so great quantities that they can be denoted as characteristic forms. The Diatoms are, however, pretty thoroughly investigated, the Peridiniaceæ and Protozoa some what less so. In the samples obtained in 1898, I have paid little attention to the small forms of the genera *Peridinium* and *Gonyaulax*. In these samples *Peridinium ovatum* Pouchet is partly confounded with *Diplopsalis lenticula* Bgh.

Of Crustaceans and other higher animals, I have only been able to include the most common species present, viz., those which play some important part in the economy of the coastal Plankton.

In order to describe the frequency I have employed Cleve's marks:

- cc. Denotes an excess (more than 9/10th of the entire sample).
- cc. Very common.
- c. Common.
- +. Somewhat numerous.
- r. Scarce.

In respect to the position of the stations, to the salinity and temperature at various depths, reference must be made to the Hydrographical Tables.

The Stations in the fiords are denoted by capital letters with numerals attached or otherwise, for instance «E1» refers to the innermost station in Eidsfiord: «E8» the outermost station beyond the fiord. «O1» the innermost. «O8» the outermost station in Ofoten.



# I. Plant-Pla

Date. May 1898.	
Station.	
N. latitude.	60°
Longitude.	E. 4
Depth in metres.	0
Temperature °C.	} of the surface water. 6.3
Salinity ‰.	
	33.02

## Bacillariales.

<i>Thalassiosira hyalina</i> (Grun.) Gran. . . . .	
<i>Coscinodiscus oculus iridis</i> Ehr. . . . .	
— <i>radiatus</i> Ehr. . . . .	
<i>Leptocylindrus danicus</i> Cl. . . . .	r
<i>Rhizosolenia semispina</i> Hensen . . . . .	
— <i>obtusa</i> Hensen . . . . .	
<i>Chaetoceras atlanticum</i> Cl. . . . .	
— <i>criophilum</i> Castr. . . . .	
— <i>decepiens</i> Cl. . . . .	
— <i>teres</i> Cl. . . . .	
— <i>constrictum</i> Gran. . . . .	
— <i>debile</i> Cl. . . . .	
— <i>cinctum</i> Gran . . . . .	
<i>Thalassiothrix longissima</i> Cl. & Grun. . . . .	
<i>Achnanthes taeniata</i> Grun. . . . .	

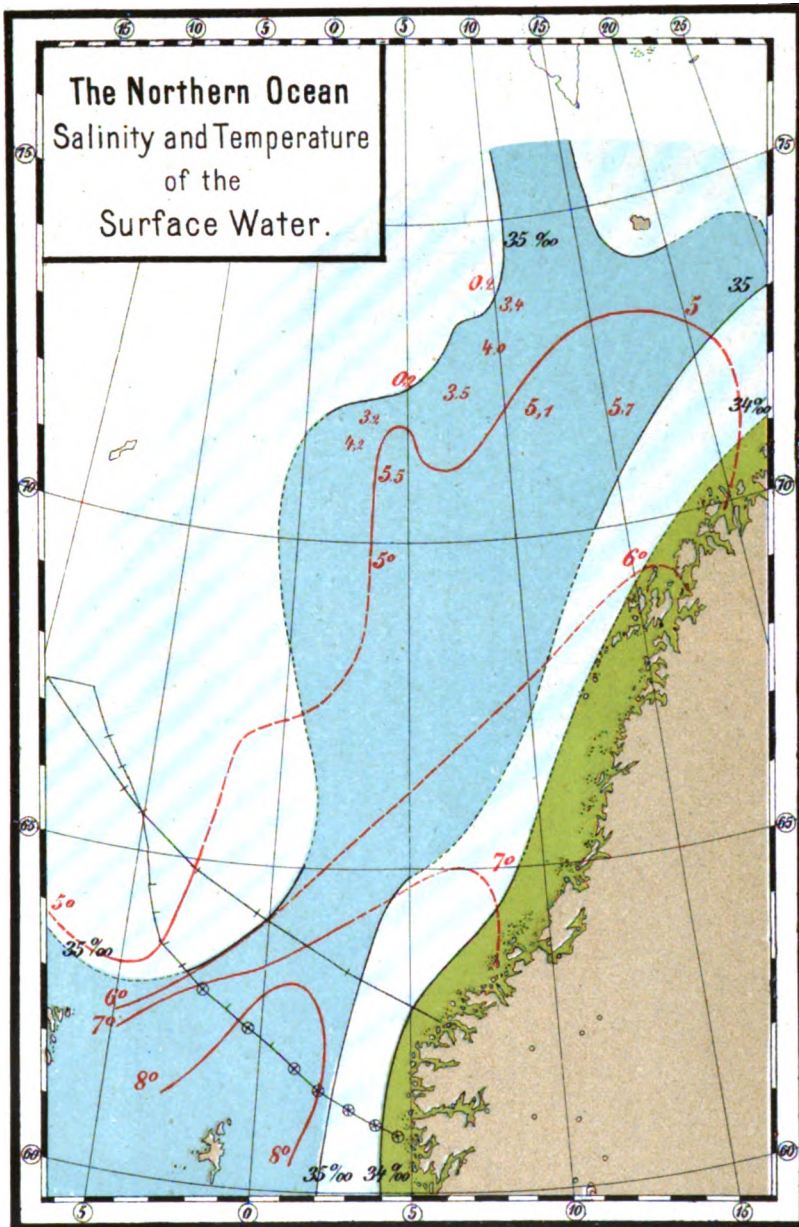
## Cilioflagellata.

<i>Ceratium tripos</i> (Duj.) Nitzsch. . . . .	cc
— <i>v. longipes</i> Bail. . . . .	cc
<i>Ceratium fusus</i> Duj. . . . .	c
— <i>furca</i> Duj. . . . .	c
<i>Peridinium divergens</i> Ehr. s. l . . . . .	c
<i>Diplopsalis lenticula</i> Bgh. . . . .	
<i>Dinophysis acuta</i> Ehr. . . . .	r

## Flagellata.

<i>Phaeocystis Pouchetii</i> (Har.) Lagh. . . . .	+
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May 1898.

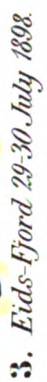
Salinity :

35‰ or more.

35‰.

below 34‰.





0







